U.S. Environmental Protection Agency

Pilot

Radiological Dispersal Device (RDD) and
Improvised Nuclear Device (IND)
Tabletop Training Exercise
Conducted in
San Francisco, California
On Monday February 26, 2007

ACKNOWLEDGEMENTS

The development of this Tabletop exercise (TTX) was a team effort led by the EPA staff of the Office of Superfund Remediation and Technology Innovation (OSRTI), the National Decontamination Team (NDT) of the Office of Emergency Management (OEM), and Region 5. The principal members of the TTX team were Stuart Walker of OSRTI, Scott Hudson and John Cardarelli of NDT/OEM, and Jim Mitchell and Gene Jablonowski of Region 5, with significant contributions from Robin Anderson and Charles Sands of OSRTI.

After the initial development of the TTX, Region 9 staff helped the team focus the team develop aspects of the TTX that were specific to San Francisco. The Region 9 contributors included Kathy Setian, Bill Roberson, and Will Duncan.

The TTX team was also assisted by Doug Sarno of the Perspectives Group under an EPA Facilitation contract.

Late-Phase Response Tabletop Training Exercise

Introduction and Resource Materials

This exercise will **explore key decisions of late-phase response to achieve final cleanup levels following a nuclear terrorist attack** under two scenarios**:**

Scenario 1. Radiological Dispersal Device (RDD or "dirty bomb")
Scenario 2. Improvised Nuclear Device (IND)

Overall Exercise Goals

1. **Experiential Learning:** Provide EPA Superfund site managers for longterm and emergency response situations (RPMs and OSCs) an opportunity to participate in an RDD/IND TTX as a learning experience.
   Desired outcome: Prepare staff for conducting such actions and help HQ gain insight into program needs for RDD/IND response.

2. **Conduct Optimization Discussions:** Have dialogue on using a CERCLA type approach as a benchmark (e.g., 10^{-4} to 10^{-6} cancer risk and ARARs) with examination of cleanups with residual risks greater than 10^{-4} (e.g., 10^{-3}, 10^{-2}).
   Desired outcome: Identify what is needed to achieve resolution of the issues between interested parties.

3. **Late-Phase Experience:** Focus on late-phase response strategies (e.g., technologies used, concentrations achieved, risk estimates, relocations, etc), NOT the emergency response process.
   Desired outcome: First-time experience in practicing late-phase response.

4. **Evaluate Current Tools:** Test the application of technical guidance that are currently available or in development, primarily EPA tools (e.g., current PRG and draft BPRG and SPRG risk assessment calculators, Decontamination documents, older OSWER guidance) in RDD and IND tabletop simulation.
   Desired outcome: Help determine future projects OSRTI and OEM need to develop.

Scenario Outcomes

- Participants will be asked to work through each scenario to identify the following:
- Proposed Land Use(s) Upon Completion of Cleanup
- Proposed Risk Levels
- Cleanup Levels for specific radionuclides
- Approaches to cleanup
- Timeframe/phasing for Cleanup
- Proposed Land Use(s) During Cleanup (if different)

Exercise Evaluation

Participants will also be asked to provide input into how the exercise can be improved over time, including:

1. What additional information would have been useful to completing the exercise?
2. What information was not useful or needed?
3. What actions are important to be conducted during the preceding (emergency) phase to help with the late phase?
4. What issues which were not part of this exercise would most affect late-phase response in real-life, and how could these be incorporated into the exercise?

Scenario Approach

In an actual RDD or IND event, it will be determined site-specifically which benchmarks, guidance and tools may be chosen to facilitate the optimization process and the late-phase cleanup. However, to help EPA determine which new tools and guidance to develop, today's TTX will focus on an EPA CERCLA-type approach for determining the optimized cleanup approach for the late-phase, which uses the following cleanup guidelines:

- A lifetime risk range of 10^{-4} to 10^{-6}
- A Hazard Index of 1
- Applicable or Relevant and Appropriate Requirements (ARARs)
- Nine decision criteria
- For the purposes of this exercise, risk levels higher than CERCLA's (e.g., 10^{-3}, 10^{-2}) may be considered

AGENDA

8:15 Background and Overview of the RDD Scenario
8:45 Introduction to Available Cleanup Technologies
9:15 RDD Exercise
12:00 Lunch
12:30 Finalize Approach to RDD
1:30 Sharing/Discussion of RDD Results and Rationale
2:30 Overview of the IND Scenario
3:30 IND Exercise
4:15 Sharing of Results and Rationale
5:00 Adjourn

KEY RESOURCE MATERIALS

1. Exercise Results Summary Table
2. Key Exercise Assumptions
3. Overview of Homeland Security Guidance on RDD/IND Cleanup
4. Optimization Approach to Late Phase Decision-making
5. Phases of Response
6. Protective Action Guides for RDD or IND Incidents
7. Suggested Examples of United States Benchmarks of Potential Use in Evaluating Long-Term Cleanup Exposure Level Options During the Late Phase
8. Overview of EPA CERCLA-type approach to Cleanup Decision Making
9. EPA Guidance Web Links
10. Background on Contamination Assumptions

1. RDD EXERCISE RESULTS SUMMARY TABLE

Complete one table for each different area/land use that you identified in your cleanup scenario.

	Recommended actions	Rationale
Description of cleanup Area		
Proposed Land Use(s) Upon Completion of Cleanup		
Proposed Risk Level		
Cleanup Levels for Am-241		
Cleanup Levels for Cs-137		
Approaches to cleanup		
Timeframe/phasing for Cleanup		
Proposed Land Use(s) During Cleanup (if different)		
Cost of Cleanup Approach		

1. IND EXERCISE RESULTS SUMMARY TABLE

Complete one table for each different area/land use that you identified in your cleanup scenario.

	Recommended actions	Rationale
Description of cleanup Area		
Proposed Land Use(s) Upon Completion of Cleanup		
Proposed Risk Level		
Cleanup Levels for Sr-90		
Cleanup Levels for Cs-137		
Approaches to cleanup		
Timeframe/phasing for Cleanup		
Proposed Land Use(s) During Cleanup (if different)		
Cost of Cleanup Approach		

2. Key Exercise Assumptions

An exercise such as today's TTX represents only a greatly simplified approximation of what would occur during an actual RDD or IND attack. Some simplified assumptions that were used in today's TTX to develop RDD and IND scenarios include:

1. In the event of an actual RDD or IND attack, NARAC plume runs are likely to be used to help first responders and federal officials make early-phase PAG decisions, such as areas to evacuate or shelter in place. For the late-phase, actual site measurements would be used to delineate contamination levels, not air deposition models such as NARAC.

2. For the purpose of today's TTX, all contamination was considered to be in removable dust. Some of this material would instead become fixed in place (e.g., streets, sidewalks, sides of buildings). Contamination that was fixed in place would result in significantly lower risks. For example under the SPRG residential scenario, Amercium-241 poses 7 orders of magnitude more risk when in dust rather than fixed, Cesium-137+D poses 3 orders of magnitude more risk, and Strontium-90+D poses 5 orders of magnitude more risk. Fixed contamination is likely more difficult to remove but could be shielded.

3. For the purpose of today's TTX, a resuspension rate of 1×10^{-4} was assumed for indoors settled dust. It is EPA's policy that indoor resuspension should not be modeled, but rather contaminant levels in ambient air should be measured. The rate of indoor resuspension varies so greatly from a variety of factors that EPA does not generally include it in its risk assessment methodology (e.g., BPRG, WTC indoor risk assessment).

4. For the purpose of today's TTX, an infiltration rate of outdoor contamination into the indoor environment of half for evacuated areas and 2 times for unevacuated areas was assumed. It is EPA's policy that indoor settled dust levels should be measured. Indoor levels and the rate of infiltration will vary by building and by contaminant.

5. For the purposes of the today's TTX, chemical (non radiological) contaminants were not included. Damage to buildings in either a RDD or IND attack would lead to the release of chemicals (e.g., PCBs, asbestos) used in building construction.

3. Overview of Homeland Security Guidance on RDD/IND Cleanup

Homeland Security Presidential Directive #5 (HSPD-5), Management of Domestic Incidents, states,

> "to prevent, prepare for, respond to and recover from terrorist attacks, major disasters, and other emergencies, the United States Government shall establish a single, comprehensive approach to domestic incident management."

It also assigns the Secretary of the Department of Homeland Security (DHS) the role of Principal Federal Official for domestic incident management.

DHS coordinated the development of "Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents" which was issued in the *Federal Register* (71 FR 174) on January 3, 2006, for interim use and comment. This document addresses the critical issues of protective actions and protective action guides (PAGs) to mitigate the effects caused by terrorist use of a Radiological Dispersal Device (RDD) or Improvised Nuclear Device (IND). This document was developed to provide guidance for site cleanup and recovery following an RDD or IND incident and affirms the applicability of existing PAGs for radiological emergencies. The intended audience of this document is Federal radiological emergency response and consequence management officials. In addition, state and local governments may find this document useful in response and consequence management planning. ***These guides are not intended for use at site cleanups occurring under other statutory authorities such as the Environmental Protection Agency (EPA) Superfund program***, the Nuclear Regulatory Commission's decommissioning program, or other Federal and state cleanup programs. In addition, the scope of this document does not include situations involving United States nuclear weapons accidents.

4. Optimization Approach to Late Phase Decision-making

Because of the extremely broad range of potential impacts that may occur from RDDs and INDs (e.g., ranging from light contamination of one building to widespread destruction of a major metropolitan area), a pre-established numeric guideline is not recommended by DHS as best serving the needs of decision makers in the late phase. Rather, an optimization process should be used to determine the societal objectives for expected land uses and the options and approaches available, in order to select the most acceptable criteria.

Optimization is a flexible approach in which one identifies a variety of dose and/or risk benchmarks from state, Federal, or other sources. For some benchmark examples, see Table 2. These benchmarks may be used for analysis of remediation options and final selected levels may move up or down depending on the site-specific circumstances and balancing of other relevant factors. If the benchmark one chooses has an optimization process built into it, then generally use the optimization process associated with the benchmarks chosen to determine final cleanup levels. For example if the CERCLA criteria is used as a benchmark, then the 9 remedy selection criteria should be used as the optimization process. If the NRC or DOE dose criteria is used as a benchmark, then the ALARA process should be used as the optimization process. Additionally, various Federal and state agencies, and other organizations have existing guidance and tools that may be used to establish recovery levels as part of the optimization process during the late phase. For example, EPA, NRC, DoD, DOE, and State programs dealing with site restoration, decommissioning and waste management have guidance and tools that may be used as part of the optimization process and to implement the recovery process.

5. Phases of Response

Typically, the response to an emergency can be divided into three time phases. Although these phases cannot be represented by precise time periods and may overlap, they provide a useful framework for the considerations involved in emergency response planning. Table 1 provides a summary of the key actions and suggested PAGs for an RDD or IND incident.

The early phase (or emergency phase) is the period at the beginning of the incident when the source (e.g., fire or contaminated plume) at the incident is active, field measurement data are limited or not available, and immediate protective action decisions are required. Exposure to the radioactive plume, short-term exposure to deposited materials and inhalation of radioactive material are generally included when considering protective actions for the early phase of a radiological emergency. The response during the early phase includes the initial emergency response actions to retrieve and care for victims, stabilize the scene, and public health protective actions (such as sheltering-in-place or evacuation) in the short term. Life-saving and first aid actions should be given priority.

The intermediate phase of the response may follow the early phase response within as little as a few hours, up to several days. The intermediate phase of the response is usually assumed to begin after the incident source and releases have been brought under control and protective action decisions can be made based on some field measurements of exposure and radioactive materials. During the intermediate phase, decisions must be made on the initial actions needed to begin recovery from the incident, reopen transportation systems and critical infrastructure, and return to some state of normal activities. For the intermediate phase, relocation PAGs of 2 rems in the first year and 500 mrems in any year after the first are considered appropriate for RDD and IND incidents. The intermediate phase PAGs for the interdiction of food and water are set at 500 mrem/yr each for RDD and IND incidents.

The late phase is the period when recovery and cleanup actions designed to reduce radiation levels in the environment to acceptable levels commence and ends when all the recovery actions have been completed. In the late phase, decision makers will have more time and information to allow for better data collection and options analyses. In this respect, the late phase is no longer a response to an "emergency situation," as in the early and intermediate phases, and is better viewed in terms of the long-term objectives of cleanup and restoration of the site to meet the needs and desires of the community and region. With the additional time and increased understanding of the situation, there will be opportunities to involve key stakeholders in providing sound, cost-effective recommendations.

6. Protective Action Guides for RDD or IND Incidents

Phase	Protective Action	Protective Action Guide	Reference
Early	Limit Emergency Worker Exposure	5 rem (or greater under exceptional circumstances)[1]	EPA PAG Manual
	Sheltering of Public	1 to 5 rems projected dose[2]	EPA PAG Manual
	Evacuation of Public	1 to 5 rems projected dose[3]	EPA PAG Manual
	Administration of Prophylactic Drugs	For potassium iodide, FDA Guidance dose values[4,5]	FDA Guidance[6]
Intermediate	Limit Worker Exposure	5 rem/yr	See Appendix 1
	Relocation of General Public	2 rems, projected dose first year Subsequent years: 500 mrem/yr projected dose	EPA PAG Manual
	Food Interdiction	500 mrem/yr projected dose	FDA Guidance[7]
	Drinking Water Interdiction	500 mrem/yr dose	EPA guidance in development
Late	Final Cleanup Actions	Late phase PAG based on optimization	

[1] In cases when radiation control options are not available or, due to the magnitude of the incident, are not sufficient, doses above 5 rems may be unavoidable. For further discussion see Appendix 1.
[2] Should normally begin at 1 rem; however, sheltering may begin at lower levels if advantageous.
[3] Should normally begin at 1 rem.
[4] Provides protection from radioactive iodine only.
[5] For other information on medical prophylactics and treatment please refer to www.fda.gov/cder/drugprepare/default.htm or www.bt.cdc.gov/radiation/index/asp or www.orau.gov/reacts.
[6] " Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies," December 2001, Center Drug Evaluation and Research, FDA, HHS (www.fda.gov/cder/guidance/5386fnl.htm).
[7]"Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies," August 13, 1998, Office of Health and Industry Programs, Center for Devices and Radiological Health, FDA, HHS (www.fda.gov/cdrh/dmqrp/84.html).

7. Suggested Examples of United States Benchmarks of Potential Use in Evaluating Long-Term Cleanup Exposure Level Options During the Late Phase

Example Organizations or Cleanup Programs	Summary of selected program-specific human health protection goals or concepts as applied to the cleanup of radiological contamination.
States NRC Agreement State Decommissioning Programs	Varies across states. Usually, decommissioning programs seek to achieve: – 25 mrem/yr primary dose constraint; – 100 mrem/yr allowable exemption – Lower levels based on the "As Low As Reasonably Achievable" (ALARA) concept. Some states have more stringent dose limits (e.g., 19, 15, or 10 mrem/yr)
Environmental Department Contaminated Site Cleanup Programs (e.g., State Superfund)	Varies across states. Usually, programs seek to achieve risk-based goals or a range of acceptable risk outcomes. Goals typically: – fall within a risk range of 10^{-4} to 10^{-6} excess lifetime cancer risk; and – include meeting existing applicable or relevant environmental regulations/standards. Some states have single risk-based standards or goals (e.g., 10^{-4}, 10^{-5}, or 10^{-6}).
Federal NRC and DOE decommissioning and site remediation programs	Site cleanups seek to achieve: – 25 mrem/yr primary dose limit; – 100 mrem/yr allowable exemption; – Lower levels based on the "As Low As Reasonably Achievable" (ALARA) concept. (For further information see: 10 CFR 20 Subpart E; and DOE Order 5400.5)
EPA Superfund remedial site cleanup program[1]	Generally, remedial actions achieve human exposures that meet: – 10^{-4} to 10^{-6} excess cancer risk; – Hazard Index of one for non-cancer toxicity or less; and, – All Applicable or Relevant and Appropriate Requirements (ARARs). These may be waived under specific circumstances. (For further information see: 40 CFR 300.430)

[1] Table presents examples only. Final cleanup goals and/or actual cleanup outcomes for a particular incident may vary depending on the circumstances of the incident. No single cleanup target is recommended for all possible incidents.

[2] Although many response programs often articulate target cleanup goals or limits in planning guidance, whether or not these levels are met or exceeded on a response-specific basis generally depends on the program context and the site-specific circumstances. Levels and concepts in this table are presented for illustration only and should not be applied to a specific incident cleanup without a thorough understanding of their derivation and application in the originating programs. Users should be aware that EPA does not use most of these other benchmarks when establishing cleanup levels under CERCLA authority. This is important to note because in a variety of circumstances, the site could become a candidate for National Priorities List (NPL) listing, even years after the radiological incident cleanup. For this reason, decision-makers at a radiological incident should carefully consider attempting to attain CERCLA standards if possible. Under CERCLA, section 105(d) provides that, if a petition for assessment is filed, and no preliminary assessment (PA) of the release has been conducted within 12 months of the petition's receipt, then EPA must either complete a preliminary assessment, or explain why an assessment is not appropriate. See also 40 CFR 3000.42(b)(5). Similarly, section 105(d) requires an evaluation of a release or threatened release under the Hazard Ranking System (HRS) if the preliminary assessment indicated it may pose a threat to human health or the environment.

8. Overview of EPA CERCLA-type approach to Cleanup Decision Making

Under CERCLA, applicable or relevant and appropriate requirements (ARARs), which are federal, and more stringent State environmental standards, are often the determining factors in setting cleanup levels for long-term remedial actions pursuant to CERCLA. (Relevant and appropriate requirements are those standards and regulations which address circumstances considered to be sufficiently similar to the circumstances being addressed at the particular site.) In cases where standards don't exist or may not be sufficiently similar to the actual situation, or may not be applicable or relevant and appropriate, or the ARAR is not sufficiently protective or has been waived, site-specific cleanup levels are generally set for:

Carcinogens at a level such that a highly-exposed individual may have a one in 10,000 to a one in 1 million increased chance of developing cancer because of an exposure to a site-related carcinogen (10^{-4} to 10^{-6} cancer risk range); and

Non-carcinogens such that the cumulative risks from exposure will not result in adverse human health effects. To assess the potential for cumulative non-carcinogenic effects posed by multiple contaminants, EPA has developed a hazard index that is derived by adding the non-cancer risks for site contaminants. Generally, a hazard index (HI) of less than one is considered protective.

The specific cleanup levels account for exposures from all potential pathways and through all environmental media (soil, ground water, surface water, sediment, air, animals or plants). Risk-based cleanup levels are developed using the reasonably anticipated land use (e.g., residential, industrial, agricultural, etc.). If meeting protective levels using the reasonably anticipated land use is not both practical and cost-effective, EPA looks to more restrictive land uses through institutional and engineering controls to achieve further reduction in potential for human exposure. In some situations, a site may reasonably be anticipated to support a range of uses, so cleanup goals may be different for different parts of the site.

In complex cases such as those involving critical infrastructure (e.g., subway system, power plant, major highway) cleanup and re-occupancy is likely to occur in phases. To re-establish the infrastructure as quickly as possible, a succession of increasingly protective cleanup levels might be developed to allow near-term re-use under controlled conditions while more comprehensive cleanup proceeds over the long-term. Although it may take a long time to achieve the final protective cleanup levels, re-occupancy of the affected area may be possible if interim cleanup can reduce short-term risks to acceptable levels during the time it takes to achieve the long-term goals.

Attainment of protective cleanup goals may be achieved through several different remediation approaches. Site cleanup may employ some combination of the following methods:

1. Removal of the material that has become contaminated,
2. Technology to remove the radionuclides from the material,
3. Technology to immobilize the radionuclides,
4. Technology to shield the public from exposure to the radionuclides, and
5. Restricting use of the site to limit exposure to the radionuclides.

Consideration of risk levels higher than CERCLA's?

However, the economic or other impacts of institutional or engineering controls on a radiological incident affected area may be so significant that it would become impracticable or too costly to meet EPA's CERCLA standards. These cases would be identified through an evaluation of remedial alternatives considering various target risk levels (possibly with and without institutional and engineering controls). For example, cleanup to industrial/commercial at 1×10^{-6}, 1×10^{-5}, 1×10^{-4}, 1×10^{-3}, and 1×10^{-2} cancer risk levels. If this is true on a site-specific basis, EPA would expect that evaluating the options that are not normally considered protective, with those options that do meet EPA CERCLA standards, pose the best chance of providing stakeholders with a clear rationale for why a cleanup level was selected at a specific radiological incident site that would not normally be considered at an EPA site.

9. EPA Guidance Web Links

EPA has issued a number of CERCLA guidance documents for addressing contaminants including radiological contaminants. EPA CERCLA guidance documents for addressing cleanup in general may be found on the Internet at:

http://www.epa.gov/superfund/action/guidance/remedy/index.htm

EPA CERCLA guidance documents for addressing radionuclides in particular may be found at:

http://www.epa.gov/superfund/resources/radiation/index.htm

10. Background on Contamination Assumptions

This section contains information on how the sources of various risk and dose based concentration levels were used in the development of the RDD and IND scenarios.

Intermediate-phase relocation dose PAGs

The concentration levels corresponding to 2 rem/yr and 500 mrem/yr used for determining relocation areas during the intermediate phase for the RDD scenario were taken from the draft DOE Operation Guidelines document being developed to support implementation of the DHS PAGs. DOE provided this draft document to EPA on November 27, 2006, in support of EPA's efforts to develop today's TTX.

Late-phase risk levels

The concentration levels corresponding to various risk levels (1×10^{-6}, 1×10^{-5}, 1×10^{-4}, 1×10^{-3}, and 1×10^{-2}) used as contamination levels for evaluation of cleanup approaches during the late-phase are taken from two draft and one existing EPA Superfund risk assessment tools, the (1) draft Building Preliminary Remediation Goals (BPRG), the (2) draft Surfaces Preliminary Remediation Goals (SPRG), and the Preliminary Remediation Goals (PRG) for radionuclides electronic calculators.

Indoor risk levels

EPA is developing the BPRG calculator to help standardize the evaluation and cleanup of radiologically contaminated buildings at which risk is being assessed for occupancy. BPRGs are radionuclide concentrations in dust, air and building materials that correspond to a specified level of human cancer risk. The contamination in building materials is assessed both on the surface and volumetrically. The BPRG calculator includes two land use scenarios: (1) residential, and (2) indoor worker.

Contamination levels in settled dust and ambient air in the residential and indoor worker scenarios were used in this TTX to develop risk based concentration levels in the indoor environment. A resuspension of settled dust was assumed, to develop a settled dust concentration that corresponded to a total indoors risk from settled dust and resuspended dust into the ambient air. Based on assumed rates of intrusion indoors from outside contamination, this total settled dust concentration was backed out to derive an outside concentration of settled dust that would result in various risk levels in evacuated and unevacuated areas.

Outdoor risk levels

The intent of SPRG calculator is to address hard outside surfaces such as building slabs, outside building walls, sidewalks and roads. SPRGs are radionuclide concentrations in dust and hard outside surface materials. The contamination in hard outside surface materials is assessed both on the surface and volumetrically. The SPRG calculator includes three land use exposure scenarios: (1) residential, (2) indoor worker, and (3) outdoor worker. Contamination levels in settled dust in the residential and outdoor worker scenarios were used to in this TTX to develop risk based concentration levels in the outdoor environment. The default inputs were changed from "California urban highway" to "California urban local" roads to adjust the amount of mechanical resuspension.

The PRG calculator was developed to address media such as soil and water. PRGs are radionuclides concentrations in soil, fish, and water, the PRG calculator includes seven land use exposure scenarios: (1) residential, (2) agricultural, (3) indoor worker, (4) outdoor worker, (5) tap water, (6) fish ingestion, and (7) soil to groundwater. The default food inputs in the agricultural scenario was modified to adjust the amount form a subsistence farmer to a more typical farm family. The residential scenario was modified to create a local park scenario.

Intrusion indoors from outside contaminants

For purposes of today's TTX exercises, we are assuming the following levels of intrusion into the indoor environment from contamination outside:

1. in areas where the public has been evacuated, the level of indoor contamination is half of the outside levels.
2. in areas where the public has ***not*** been evacuated, the level of indoor contamination is 2 times greater than the outside levels.

The half (50%) value for evacuated areas is based on the findings of a study of indoor dust and smoke samples at two buildings near ground zero that had been evacuated after the 911 World Trade Center incident, in comparison to outside contamination levels (see "Comparisons of the Dust/Smoke Particulate that Settled Inside the Surrounding Buildings and Outside on the Streets of Southern New York City after the Collapse of the World Trade Center" Yiin, et al., Journal of the Air & Waste Management Association, see pages 518 and 522). This study found that indoor samples were 50-67% lower than values obtained from the outdoor samples.

The 2 times value for unevacuated areas is based on a recommendation in a study of indoor dust at contaminated sites (see "The Critical Role of House Dust in Understanding the Hazards Posed by Contaminated Soils" Paustenbach, Finley and Long, International Journal of Toxicology, 1997, see page 353). This study recommended an assumption that house dust contains 2 to 5 times the level of a contaminant than exterior soil.

Two other studies that were consulted appeared to support these assumptions, particularly regarding inorganic contaminants. These were:

1. "Outdoor-Indoor Levels of Six Air Pollutants" Thompson, Hensel, and Kats, Journal of the Air Pollution Control Association, 1973, see page 885

2. "Air pollutant penetration through airflow leaks into buildings" Liu, Lawrence Berkeley Nation Laboratory, 2002, see pages 16-18.

Resuspension of indoor settled dust

For the purposes of today's TTX, an indoor resuspension rate of 1×10^{-4} was assumed for settled dust. This recommendation was taken from a report (see "Surface Contamination: Decision Levels", Healy, Los Alamos Scientific Library, 1971, see page 32. http://library.lanl.gov/cgi-bin/getfile?00399244.pdf). The findings on resuspension of the Los Alamos report are referenced in a recent NAS report ("Reopening Public Facilities After a Biological Attack" see pages 97 to 99. http://darwin.nap.edu/books/0309096618/html/97.html).

11. Potential Modeling Improvements

This section contains information on various improvements that the TTX designers thought could potentially be made for modeling for the TTX in the future. This list will be added to and modified based upon results of the TTX.

1. Develop slope factors based on particle size.
   -- Work underway at Oak Ridge National Laboratory.

2. Develop/revise air deposition models to estimate total risk from different radionuclides and different particle sizes.

3. Develop methodology or model to estimate percentage of material that would be in dust rather than becoming fixed to hard surfaces (e.g., streets, sidewalks, sides of building).

4. Develop methodology or model to estimate percentage of settled dust on hard surfaces that would dissipate due to weathering.

5. Improve methodology for estimating amount of surfaces (e.g., lawns, building interiors, streets, sidewalks, sides of buildings) for given locations.
   -- Better GIS based software expected out by this summer.

Please add other ideas **prior** to review by others not on the TTX team. These ideas should improve the technical aspects of the TTX (e.g., underlying science), and not those organizational ideas for revamping TTX.

Scenario 1.
Radiological Attack – Radiological Dispersal Devices

Background
The Universal Adversary (UA) purchases stolen cesium chloride (CsCl) and americium to make a radiological dispersal device (RDD), or "dirty bomb." The explosive and the shielded cesium-137 (Cs-137) and americium-241 (Am-241) sources are smuggled into the Country. Detonator cord is stolen from a mining operation, and all other materials are obtained legally in the United States.

At 11:15 a.m. on November 1, 2006, UA members detonate the 3,000-pound truck bomb containing the 2,300 curies of Cs-137 and 50 curies of Am-241 in an undisclosed location in San Francisco. The explosion collapses the front of one building and causes severe damage to three others. Windows are blown out of five other buildings. Amid the destruction, Cs-137 and Am-241 contamination covers the scene and the contaminated detonation aerosol is lifted more than 100 feet into the air.

The attack has no advance notice or intelligence that indicates its possibility. The explosions are instantaneous, but plume dispersion continues for 20 minutes while breezes navigate the complex environments before particles have fully settled. First responders do not recognize radioactive contamination for 15 minutes.

As a result of the explosions, 90% of the 2,300 curies Cs-137 and 82% of the 50 curies Am-241 sources is aerosolized and carried by winds, with radioactive particles ranging in size from 0.1 micron to 1,000 microns. The remaining fallout deposits debris and contaminates surrounding structures.

A disposal facility is available for cleaning up waste.

Human Impact
- 180 fatalities
- 270 injuries,
- Extensive environmental contamination
- Relocation of 79,200 persons in first year PAG (2 rem/yr) relocation zone.
- Relocation of 139,000 persons in second year PAG (500 mrem/yr) relocation zone.
- Hundreds of thousands self-evacuate from major urban areas in anticipation of future attacks
- 3.91 million individuals residing in the area exposed to over EPA deminimis (1×10^{-6}) and 1.62 million exposed to over EPA health based levels (1×10^{-4}).

Infrastructure Damage
Limited to the immediate vicinity of the explosion

Economic Impact
Up to billions of dollars

Potential for Multiple Events
Yes

Recovery Timeline
Months to years

Contaminants of Concern

Cs-137 is a gamma emitter that will still pose a threat even if not inhaled or ingested. Cs-137 is mostly used in the form of CsCl because it is easy to precipitate. CsCl is a fairly fine, light powder with typical particle size median at about 300 microns. Fractions below 10 microns are typically less than 1%. In an RDD, most will fall out within approximately 1,000 to 2,000 feet (although many variables exist), but a smaller amount may be carried great distances, even hundreds of miles.

Am-241 is an alpha emitter that poses a health threat when inhaled or ingested.

Extent of Contamination

- 2.9 kilometers (1.8 miles) and 3.2 square kilometers (1.2 square miles) in first year PAG (2 rem) relocation zone.
- 4.1 kilometers (2.5 miles) and 6.8 square kilometers (2.6 square miles) in second year PAG (500 mrem/yr) relocation zone.
- 39 kilometers (24 miles) and 152 square kilometers (58.7 square miles) over 100 times the EPA health based levels (1×10^{-2} cancer risk) for residential land use indoors in non evacuated areas. 3.91 million persons in this area.
- 120 kilometers (75 miles) and 1,486 square kilometers (574 square miles) over 10 times the EPA health based levels (1×10^{-3} cancer risk) for residential land use indoors in non evacuated areas. 3.91 million persons in this area.
- 121 kilometers (75 miles) and 2,972 square kilometers (1,147 square miles) over EPA health based levels (1×10^{-4} cancer risk) for residential land use indoors in non evacuated areas. 1.62 million persons in this area.
- 136 kilometers (85 miles) and 6,819 square kilometers (2,633 square miles) over EPA de minimis levels (1×10^{-6} cancer risk) for residential land use indoors in non evacuated areas. 3.91 million persons in this area.

The contaminated region above 1×10^{-4} covers approximately 1,147 square miles and includes the business district (high-rise street canyons), residential row houses, and crowded shopping areas.

The entire scene is contaminated with Cs-137, though not at levels causing immediate concern to first responders. Due to the size of the explosion, the radioactive contamination is blown widely such that the ground zero area is not as radioactive as

might have been expected. The detonation aerosol contains 90% of the original Cs-137 source with radioactive particles whose sizes range from 1 micron (or micro-meter, μm) to 150 microns – the size of most of the particles is approximately 100 microns. Larger particles either penetrate building materials in the blast zone, or drop quickly to the ground as fall-out within about 500 feet.

Variable winds carry the radioactively contaminated aerosol throughout an area of approximately 121 kilometers (the deposition zone above EPA's 1 x 10^{-4}). Complex urban wind patterns carry the contamination in unpredictable directions, leaving highly variable contamination deposition with numerous hot spots created by wind eddies and vortices. Radioactivity concentrations in this zone are on the order of 5-50 microcuries/m^2, with hot spots measuring 100-500 microcuries/m^2; however, traces of the Cs-137 plume carry more than 136 kilometers on prevailing winds. Negative indoor building pressure draws radioactive aerosols into buildings via cracks around windows and doors. Exterior air intakes increase the contamination in the interior of larger buildings. The subway system is contaminated by radioactive aerosols entering through subway ventilation system air intakes.

Foot and vehicular traffic after deposition re-suspend and transfer contamination for hours afterward until the entire scene has been effectively controlled and cordoned, contributing to contamination spread. People who were in the deposition zone also take contamination home with them in hair and clothing.

Service Disruption

Transportation is severely hampered in each city. Bus, rail, and air transport routes are altered, and officials build highway checkpoints to monitor incoming traffic for contamination. The subway system is completely or partially closed for an extended period. The entire relocation zone is closed to all traffic for an extended period (though peripheral areas and some thoroughfares are opened within several weeks for limited use). Hospitals in each region, already at maximum capacity with injuries from the blasts, are inundated with up 50,000 "worried well," most of whom were not in the blast or plume zone but are concerned about health issues (despite special relief stations established by the incident command for contamination monitoring and public outreach).

The sewage treatment plant is quickly contaminated as a result of people showering and decontaminating personal effects. Businesses are closed for an extended duration while radioactive contamination is remediated. Local tax revenues plummet, and people discover that insurance claims are rejected. The schools in the relocation zones are closed and students meet in alternate locations. Nearby towns and cities close their doors to residents of the impacted cities for fear of contamination spread. Bus, rail, and air transport routes are altered, and officials build highway checkpoints to monitor incoming traffic for contamination.

Decontamination/Cleanup

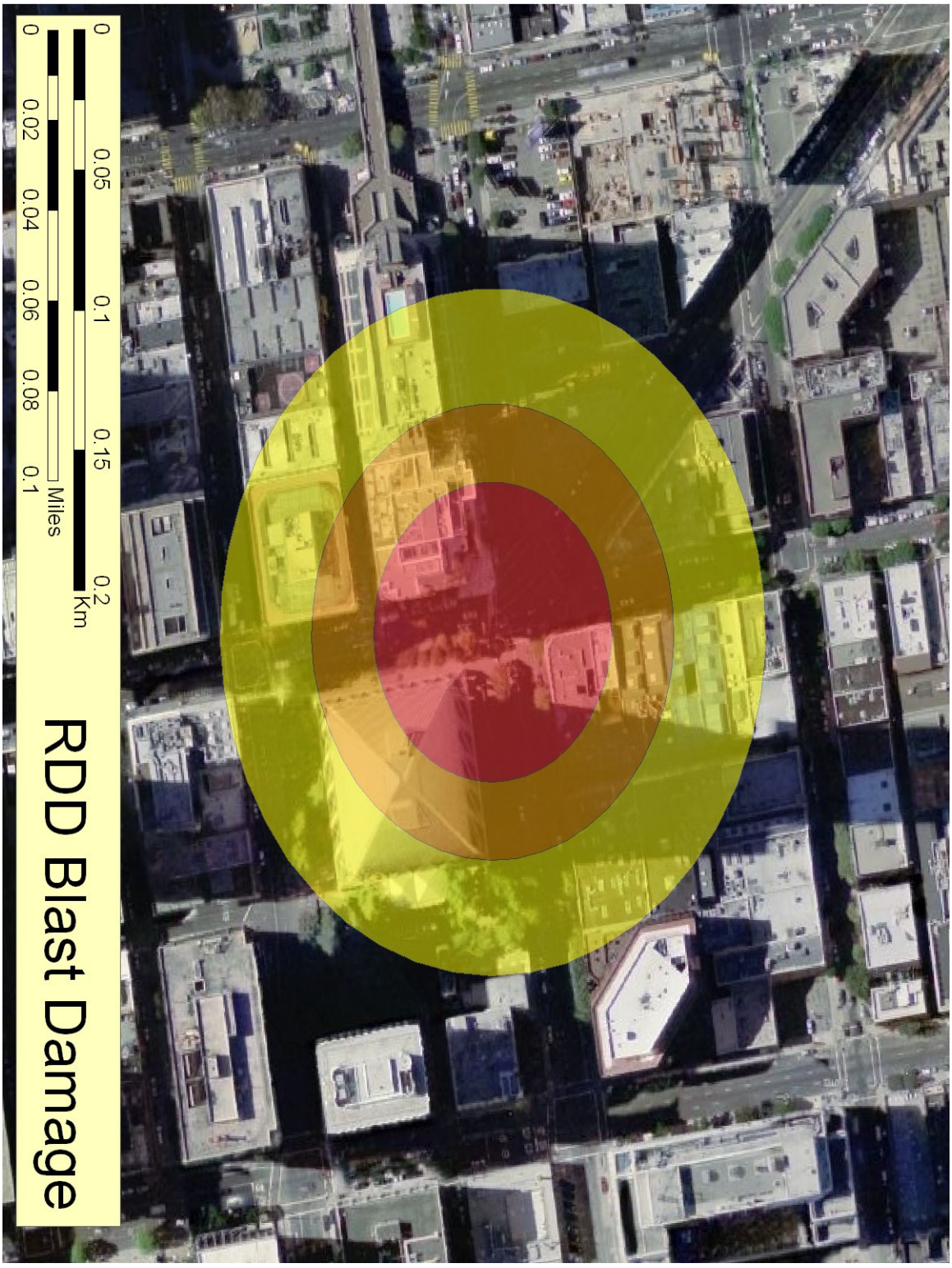
The extent of contamination will be a major challenge because Cs-137 is highly water-soluble and is chemically reactive with a wide variety of materials, including common building materials such as concrete and stone. Approximately 1,147 square miles will be contaminated over 1 x 10^{-4} levels, and 2,633 square miles over 1 x 10^{-6} levels. Contamination will settle on streets, sidewalks, and building surfaces, and will be found in several kilometers of the subway system. Building interiors will become contaminated due to ventilation systems, doors, windows (because negative building pressure can draw aerosols in through very small openings), and foot traffic. Personal property – including vehicles and items inside buildings – will also become contaminated, but many items can be adequately decontaminated for free release. The destruction/damage to structures caused by the initial blast has resulted smaller amounts chemical (e.g., lead, asbestos, and Polychlorinated Biphenyls (PCBs)) in the downtown area.

Response Actions in Early and Intermediate Phases

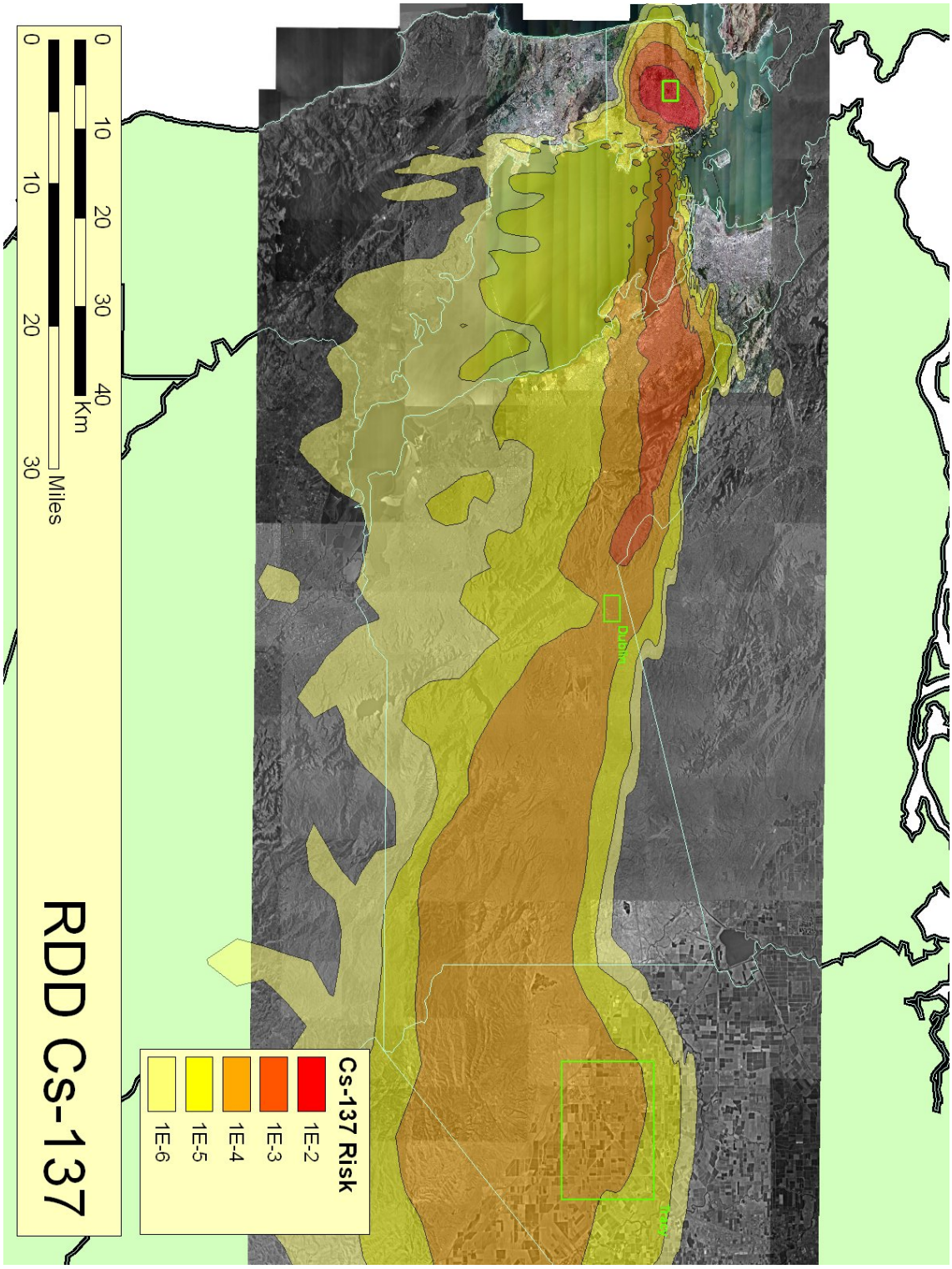
During the early and most likely the intermediate phase to return critical infrastructure and other areas to reuse before the onset of late-phase effects. The effects of these early and intermediate were not included in this exercise.

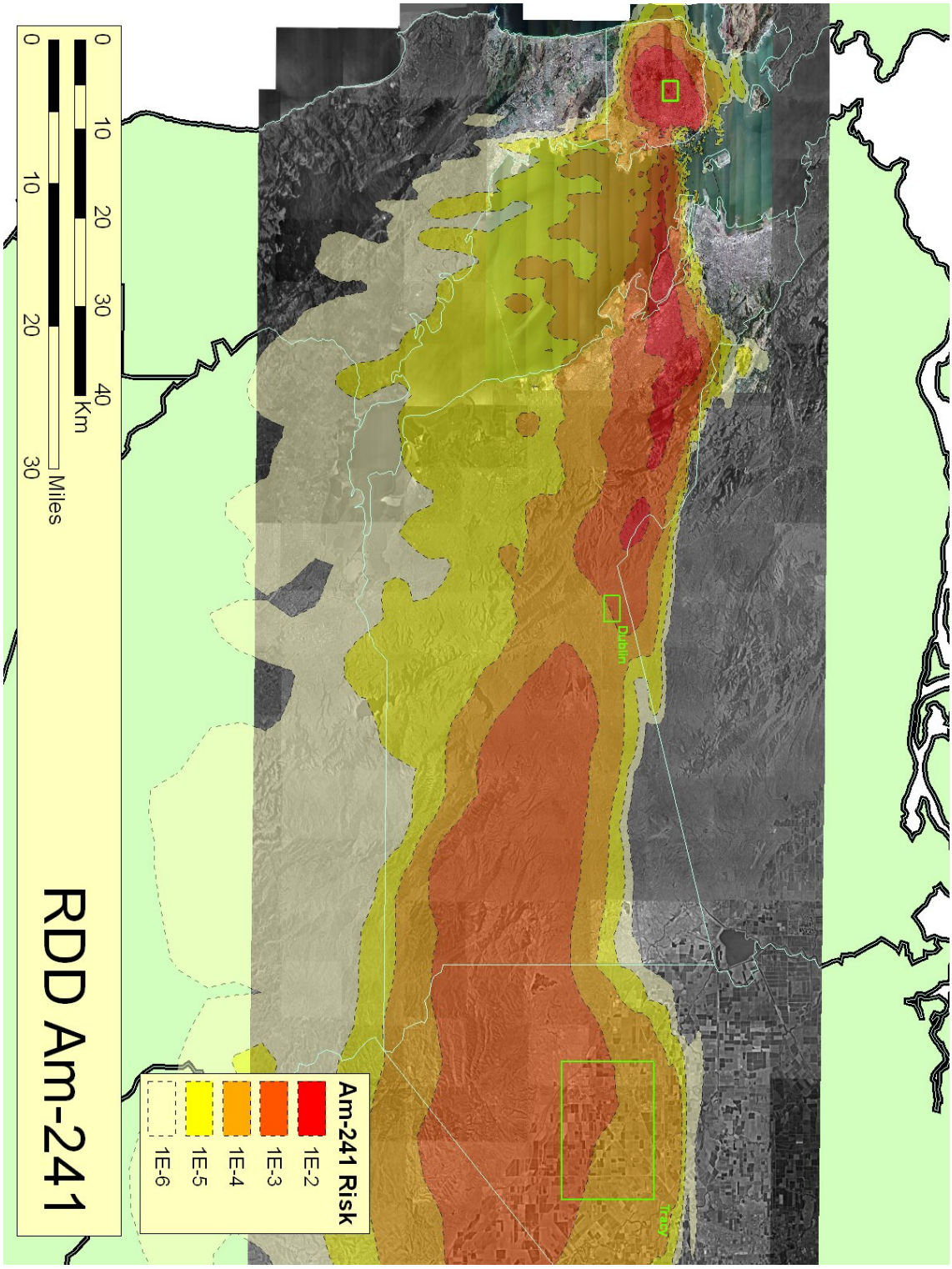
The following resource maps included here were used in the TTX:

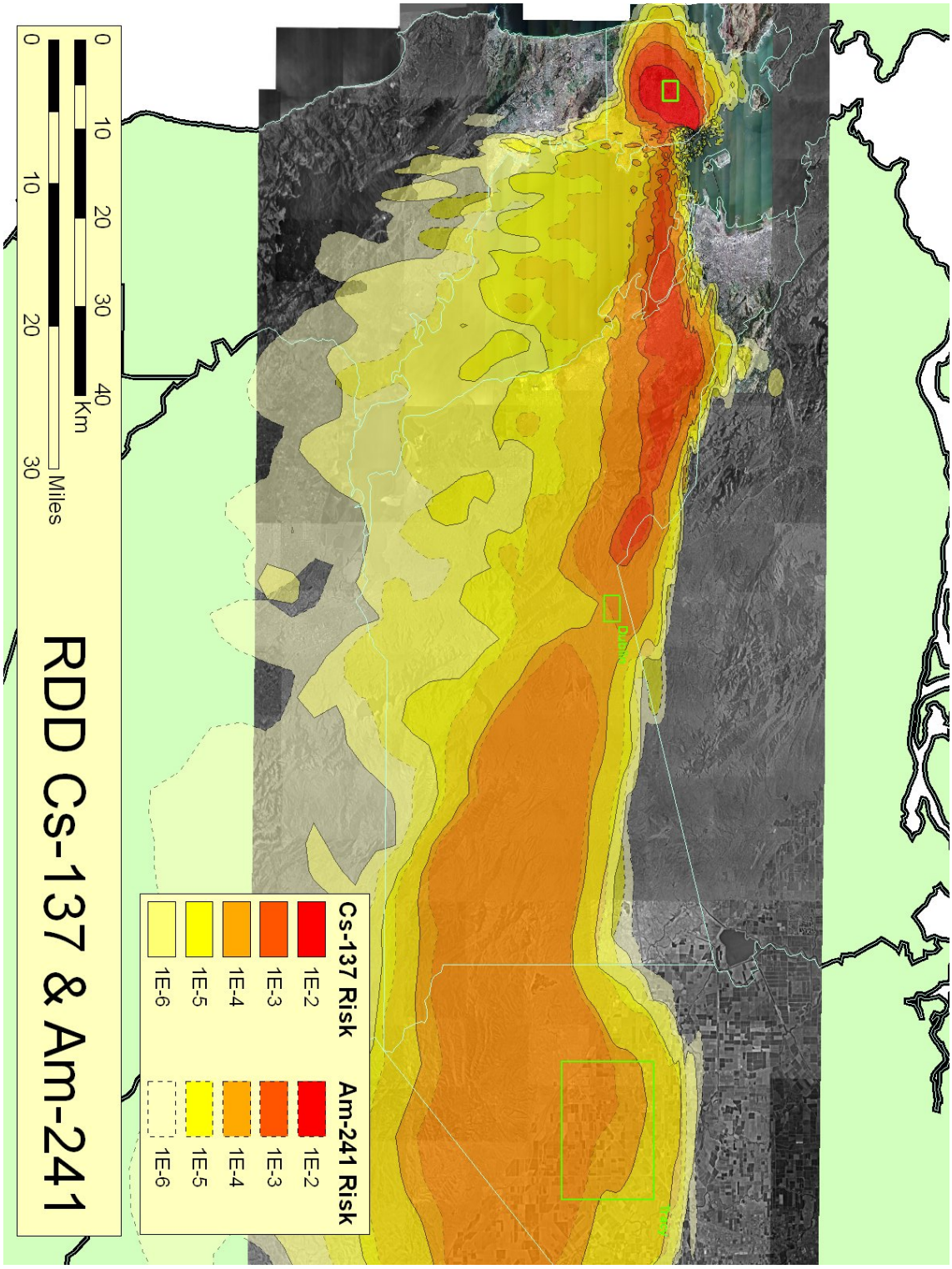
1. RDD Blast damage
2. RDD Relocation area
3. Cesium settled dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads.
4. Americium settled dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads
5. Americium and cesium combined settled dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads


RDD Blast Damage
0
0.05
0.1
0.15
0.2
Km
0
0.02
0.04
0.06
0.08
0.1
Miles

RDD Relocation Area
0
0.5
1
1.5
2
Km
0
0.3
0.6
0.9
1.2
1.5
Miles
2000 mREM/year
500 mREM/year


RDD Cs-137
0 10 20 30 40 Km
0 10 20 30 Miles
Cs-137 Risk
1E-2
1E-3
1E-4
1E-5
1E-6


RDD Am-241
0 10 20 30 40 Km
0 10 20 30 Miles
Am-241 Risk
1E-2
1E-3
1E-4
1E-5
1E-6
Dublin
Tracy


RDD Cs-137 & Am-241
0 10 20 30 40 Km
0 10 20 30 Miles
Cs-137 Risk
1E-2
1E-3
1E-4
1E-5
1E-6
Am-241 Risk
1E-2
1E-3
1E-4
1E-5
1E-6

Discrete Areas

During the TTX, the participants were split into three technical workgroups. Each of these three technical workgroups was tasked to focus on the cleanup of one of three discrete areas. The discrete areas were picked as representative urban, suburban, and rural areas that had been impacted by the RDD. These three discrete areas were:

1. Haight-Ashbury (urban)

2. Dublin (suburban)

3. Tracy (rural)

Each of the three technical workgroups reviewed the following handouts to facilitate determining what response approach they would recommend is used to address the discrete areas:

1. Aerial photograph showing each discrete area.

2. Baseline risk assessment chart for each discrete area showing the level of risk posed by the cesium and americium contamination levels under different exposure scenarios representing land use, roadway types, settled dust or fixed contamination, and indoor or outdoors.

3. California roadway classification map for matching roads in discrete areas to correct exposure scenario in the baseline risk assessment chart.

4. Decontamination technology fact sheet *(same for each discrete area).*

5. Decontamination technology spreadsheet for tabulating costs for each discrete area.

RDD Relocation (2nd Year)
2000 mREM
500 mREM
0
0.1
0.2
0.3
0.4
Miles
0
0.1
0.2
0.3
0.4
0.5
km
Haight-Asbury Area
Risk exceeds: 1E-2 for Cs-137 & Am-241
N

RDD Table to use "RDD scenario risks Haight Ashbury ver 2.xls"

Baseline Risk Assessment Table: RDD Haight Ashbury **Urban**

Pre-remedial Concentrations *Outside*; Americium 10 pCi/cm2 Cesium-137+D 6,000 pCi/cm2

Pre-remedial Risk from *Outside* Concentrations

	Risk if Residential Urban local Rd [1]	Risk if Outdoor Worker Urban local Rd [2]	Risk if Indoor Worker Urban local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Americium-241	1.00E-01	2.04E-01	9.09E-02	1.56E-02	1.02E-02	7.25E-03
Cesium-137+D	1.68E-01	1.25E-01	1.04E-01	8.81E-02	1.50E-01	8.78E-02

	Risk if Residential Urban Other Principal Arterial [7]	Risk if Outdoor Worker Urban Other Principal Arterial [8]	Risk if Indoor Worker Urban Other Principal Arterial [9]	Risk if Residential Urban Minor Arterial [10]	Risk if Outdoor Worker Urban Minor Arterial [11]	Risk if Indoor Worker Urban Minor Arterial [12]
Americium-241	1.78E+01	3.69E+01	1.64E+01	9.01E+00	1.86E+01	8.26E+00
Cesium-137+D	3.49E+00	7.34E+00	3.31E+00	1.83E+00	3.75E+00	1.71E+00

	Risk if Residential Urban Collector [13]	Risk if Outdoor Worker Urban Collector [14]	Risk if Indoor Worker Urban Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]
Americium-241	4.48E-01	9.26E-01	4.13E-01	2.15E-06	1.11E-06	4.93E-07
Cesium-137+D	2.33E-01	2.68E-01	1.68E-01	2.11E-02	1.15E-02	5.08E-03

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]
Americium-241	4.88E-10	5.35E-06	1.75E-06	8.33E-07
Cesium-137+D	1.02E-03	1.01E-01	5.31E-02	2.37E-02

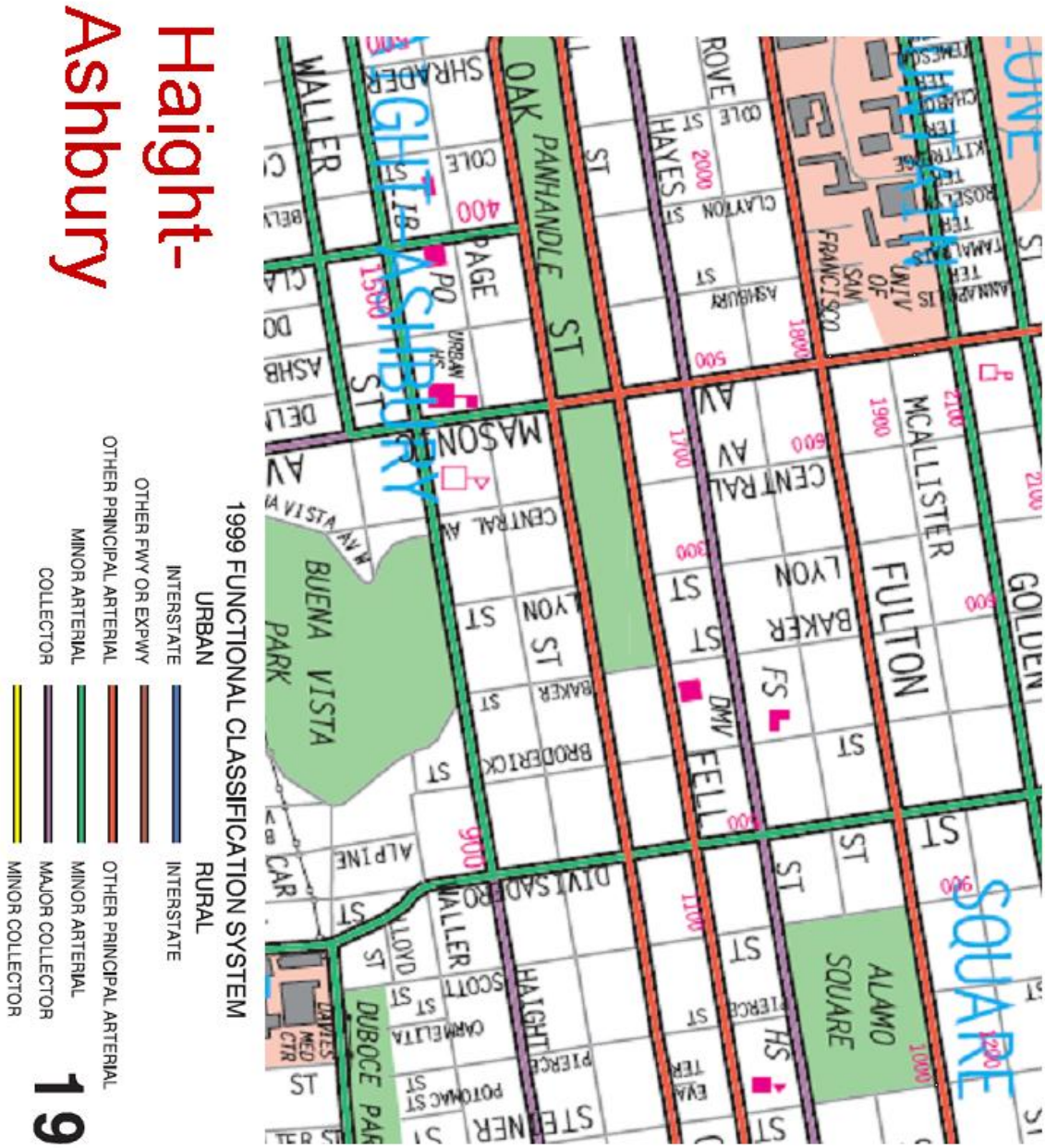
Pre-remedial Risk from *Inside* Concentrations

	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg_Comm/Ind [28]	Risk from Fixed 3-D if if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if Inside Evacuated Bldg Comm/Ind [30]
Americium-241	5.75E-03	3.03E-04	1.44E-03	7.56E-05	1.67E-05	3.33E-06	4.17E-06	8.33E-07
Cesium-137+D	6.35E-01	1.24E-01	1.59E-01	3.10E-02	1.59E-01	3.31E-02	3.96E-02	8.29E-03

RDD Table to use footnotes "RDD scenario risks Haight Ashbury ver 2.xls"

1 SPRG risk for Resident outside with California urban local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California urban local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California urban local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California urban other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California urban other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California urban other principal arterial (PEFm). 10 SPRG risk for Resident outside with California urban minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California urban minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California urban minor arterial (PEFm). 13 SPRG risk for Resident outside with California urban collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California urban collector (PEFm). 15 SPRG risk for Indoor Worker outside with California urban collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEFw. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEF. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG fixed 3-D. 28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D.

	Soil Volume (g)	Ground Plane (cm²)	For these 4 scenarios we had to assume
Am-241	2.76E-08	1.90E-08	that the slope factors were reasonably
Cs-137+D	2.55E-06	5.09E-07	close to ratio concentrations of different
Sr-90+D	1.96E-08	1.71E-08	units.


Haight-Ashbury
1999 FUNCTIONAL CLASSIFICATION SYSTEM
URBAN
INTERSTATE
OTHER FWY OR EXPWY
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
COLLECTOR
RURAL
INTERSTATE
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
MAJOR COLLECTOR
MINOR COLLECTOR
1999
BUENA VISTA PARK
ALAMO SQUARE
FULTON
MCALLISTER
CENTRAL AV
LYON
BAKER
HAYES
PANHANDLE
OAK
MASONIC
WALLER
SHRADER
COLE
PAGE
HAIGHT
DIVISADERO
FELL
DMV
FS
HS
DUBOCE PARK
SQUARE
GOLDEN

Tech Specs "Calculated Results ver6.xls"

Decon method	Surface type	Rate (sq ft/hr)	manpower /unit	DF	Fixed costs ($/unit)	Variable costs ($/sq ft) *	Waste (lb/sq ft)	Waste Type	Waste Notes
Hotwash	any	350	2	4	$3,000	$4	3	liquid	liquid waste
Hotwash w/ chelator	any	350	2	8	$3,000	$4	3	liquid	liquid waste
Steam vacuum cleaning	any	150	3	20	$10,000	$14	2	solid	Waste is dirty slurry
Dry vacuum	any	125	2	10	$500	$2	0.5	solid	Dirt, dust, fibers
TechXtract	hard, chem resistant	15	3	7	$4,000	$21	0.8	liquid	liquid waste
ALARA 1146 Strippable coating	hard	133	3	7	$0	$5	0.25 / coat	solid	Waste is mostly coating material and paint waste
Concrete scabbling (1/4" deep)	concrete	200	3	200	$12,000	$2	3 / pass	solid	Waste is concrete rubble
Concrete cutting (1" deep)	concrete	70	3	500	$12,000	$5	12	solid	Waste is concrete rubble
Media blasting	hard	100	3	100	$12,000	$5	0.75 / pass	solid	Waste is dry solid, sandy or dusty
Deep plowing	soil	43560	1	10	$50,000	6.89E-04	0	solid	
Soil excavation (skim)	soil	13068	2	10	$50,000	1.61E-03	18.37	solid	for 2" removal
Road resurface (pave over)	road	1015	10	na	$200,000	$1.40	0	solid	
Paving (new road)	road	244	20	na	$500,000	$9.50	95	solid	20' wide by 9" deep concrete highway @ 2.35 g/cc

Original Rate (sq ft/hr)	Original Variable costs ($/sq ft) *
350	$4
350	$4
150	$14
125	$2
15	$2.5K / day
133	$5
200	$2
70	$5
100	$5
1 acre/hr	$30 / acre
0.3 acre/hr	$70 / acre
weeks	$100K-200K / mi
months	$1M / mi

43560 ft^2/acre

assumes120ft^2 per day based on 8 hours per day and rate of 15 ft^2/hr. At $2.5K per day comes to $21 ft^2

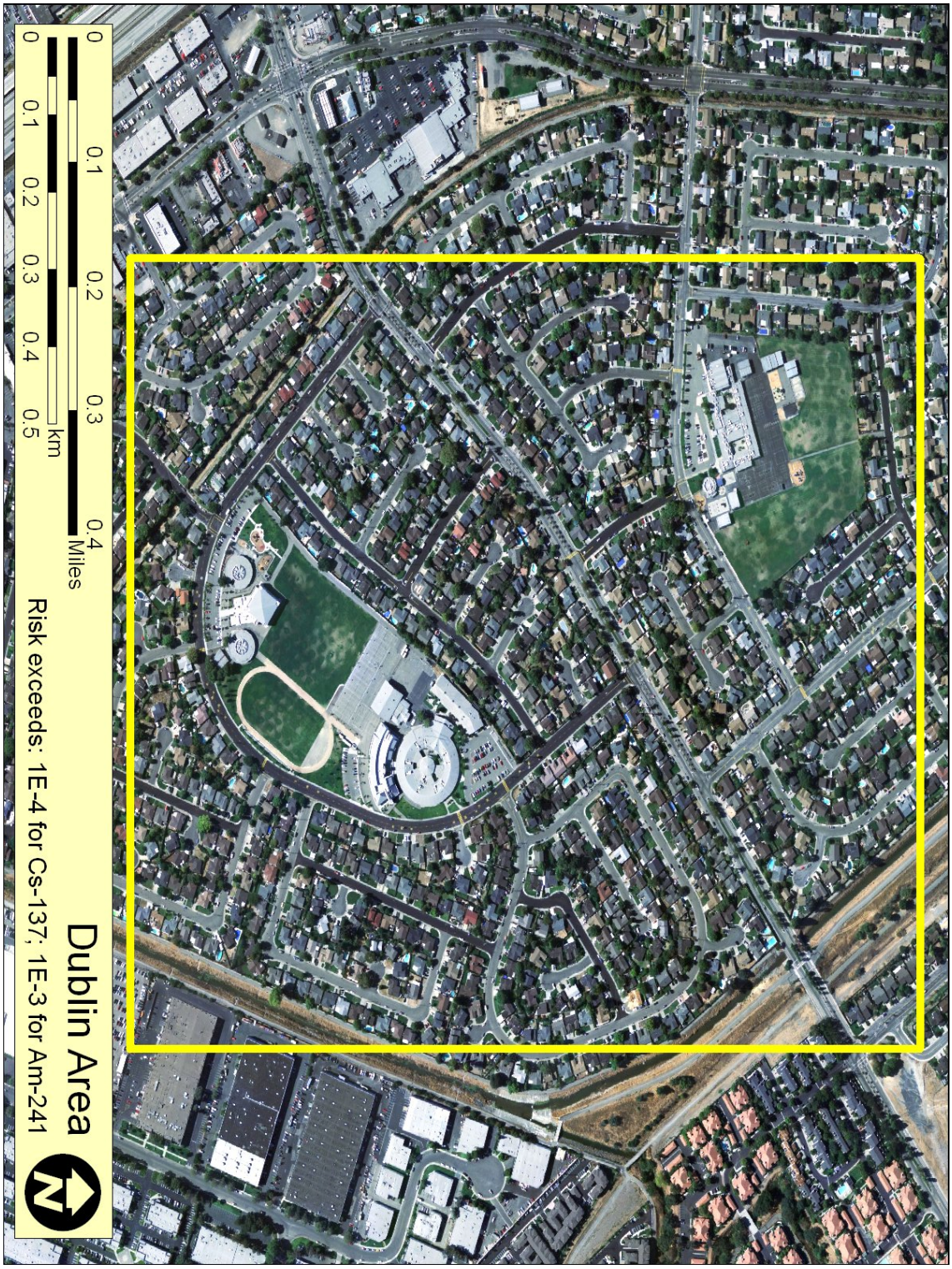
I'm assuming weeks = 2.5 (13 work days or 104 hours) and months=2.5 (54 work days or 432 hours). Also using $150K. 5280 ft per mile and assuming the road is 20 ft wide is 105600 ft^2.

I converted ton to pounds and acre to ft^2. The blasting, scabbling and ALARA are impossible for me to guess. Will use previous assumptions for road area

Urban (Haight Ashbury) "Calculated Results ver6.xls"

Land Use/ building use		Sub Area extent	Total Extent	Technology Selected	Unit Cost	Rate (sq ft/hr)	Variable costs ($/sq ft) *	DF	Total Costs	Manpower / unit	Total Manhours	Unit Solid Waste	Total Solid Waste	Unit Liquid Waste	Total Liquid Waste
Building exteriors	Original	8057949		Concrete scabbing (1/4" deep)	$12,000	200	$2	200	$16,127,898	3	120869	3 / pass	#VALUE!		0
	Post Cleanup														
Res. Interiors (evacuated)	Original	98230887		ALARA 1146 Strippable coating	$0	133	$5	7	$476,419,802	3	2215734	0.25 / coat	#VALUE!		0
	Post Cleanup														
Res. Interiors (non-evac)	Original	229205406		Concrete scabbing (1/4" deep)	$12,000	200	$2	200	$458,422,812	3	3438081	3 / pass	#VALUE!		0
	Post Cleanup														
Ind. Interiors (evacuated)	Original	13165199		Media blasting	$12,000	100	$5	100	$60,571,915	3	394956	0.75 / pass	#VALUE!		0
	Post Cleanup														
Ind. Interiors (non-evac)	Original	307187901		ALARA 1146 Strippable coating	$0	133	$5	7	$148,986,132	3	692905	0.25 / coat	#VALUE!		0
	Post Cleanup														
Local Parks/	Original	1622121		Deep plowing	$50,000	43560	$0	10	$51,117	1	37	0	0		0
	Post Cleanup														
Lawns	Original	1139252		Soil excavation (skim)	$50,000	13068	$0	10	$51,831	2	174	18.37	20928059		0
	Post Cleanup														
Local streets	Original	1940701		ALARA 1146 Strippable coating	$0	133	$5	7	$9,412,400	3	43775	0.25 / coat	#VALUE!		0
	Post Cleanup														
Highways	Original			ALARA 1146 Strippable coating	$0	133	$5	7	$0	3	0	0.25 / coat	#VALUE!		0
	Post Cleanup														
Drives and parking lots	Original	336491		Road resurface (pave over)	$200,000	1015	$1	na	$671,087	10	3315	0	0		0
	Post Cleanup														
Totals	Original								$1,170,714,994				#VALUE!		0
	Post Cleanup														

	one neighborhood area	all area in plume	select decon method from dropdown	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet	fixed cost + (area*$/area)	automatic from tech specs sheet	(area/sq ft/hr)* manpower	automatic from tech specs sheet	area * unit solid waste	automatic from tech specs sheet	area * unit liquid waste


Dublin Area
Risk exceeds: 1E-4 for Cs-137; 1E-3 for Am-241
0 0.1 0.2 0.3 0.4 Miles
0 0.1 0.2 0.3 0.4 0.5 km

RDD Table to use "RDD scenario risks Dublin ver 2.xls"

Baseline Risk Assessment Table: RDD Dublin **Suburban**

Pre-remedial Concentrations *Outside*: Americium 0.1 pCi/cm2 Cesium-137+D 36 pCi/cm2

Pre-remedial Risk from *Outside* Concentrations

	Risk if Residential Urban local Rd [1]	Risk if Outdoor Worker Urban local Rd [2]	Risk if Indoor Worker Urban local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Americium-241	1.00E-03	2.04E-03	9.09E-04	1.56E-04	1.02E-04	7.25E-05
Cesium-137+D	1.01E-03	7.52E-04	6.26E-04	5.29E-04	9.02E-04	5.27E-04

	Risk if Residential Urban Other Principal Arterial [7]	Risk if Outdoor Worker Urban Other Principal Arterial [8]	Risk if Indoor Worker Urban Other Principal Arterial [9]	Risk if Residential Urban Minor Arterial [10]	Risk if Outdoor Worker Urban Minor Arterial [11]	Risk if Indoor Worker Urban Minor Arterial [12]
Americium-241	1.78E-01	3.69E-01	1.64E-01	9.01E-02	1.86E-01	8.26E-02
Cesium-137+D	2.09E-02	4.41E-02	1.99E-02	1.10E-02	2.25E-02	1.03E-02

	Risk if Residential Urban Collector [13]	Risk if Outdoor Worker Urban Collector [14]	Risk if Indoor Worker Urban Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]
Americium-241	4.48E-03	9.26E-03	4.13E-03	2.15E-08	1.11E-08	4.93E-09
Cesium-137+D	1.40E-03	1.61E-03	1.01E-03	1.27E-04	6.88E-05	3.05E-05

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]
Americium-241	4.88E-12	5.35E-08	1.75E-08	8.33E-09
Cesium-137+D	6.13E-06	6.03E-04	3.19E-04	1.42E-04

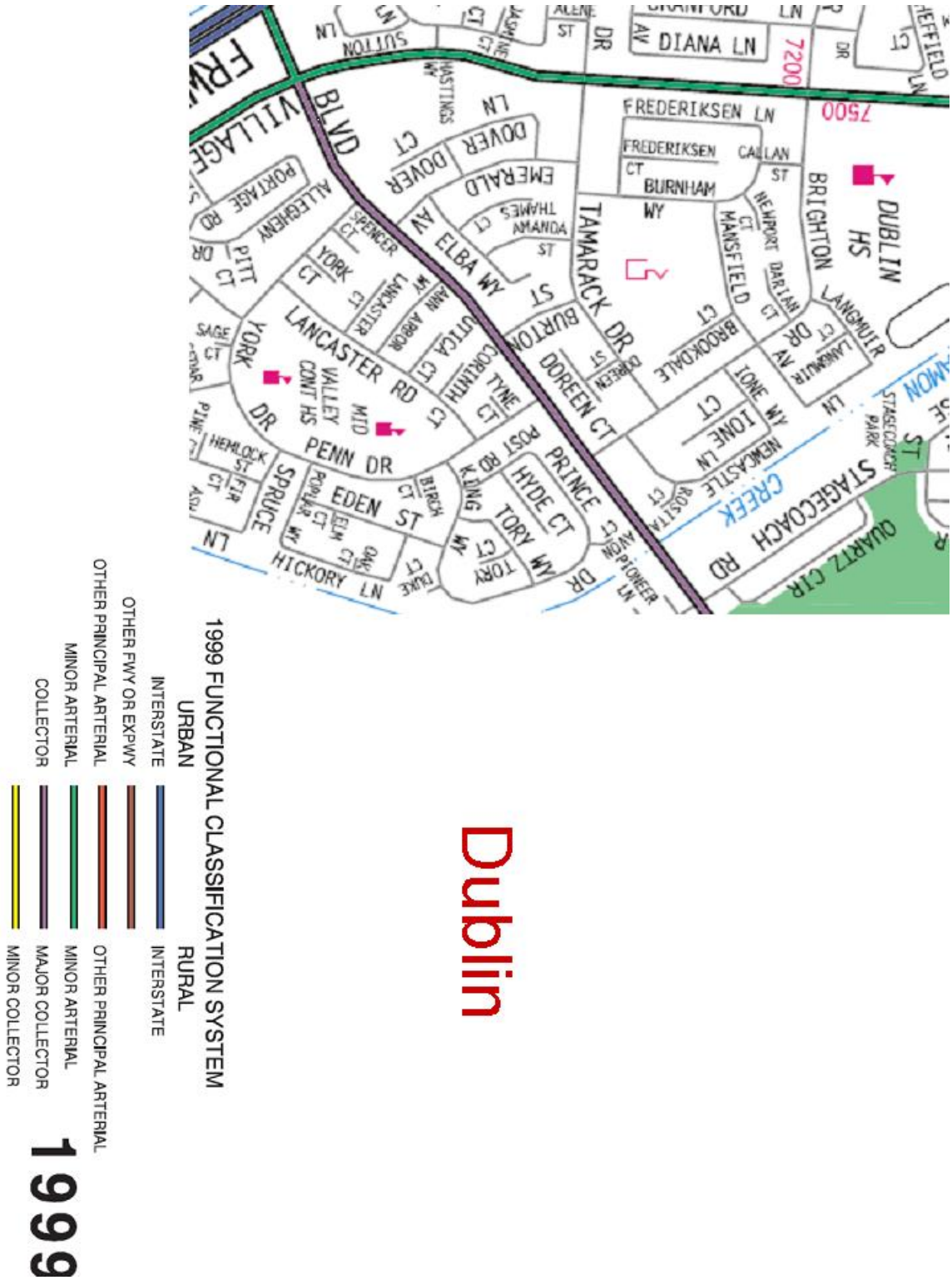
Pre-remedial Risk from *Inside* Concentrations

	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [28]	Risk from Fixed 3-D if Inside Unevacuated Bldg Comm/Ind [28]	Risk from Fixed 3-D if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if Inside Evacuated Bldg Comm/Ind [30]
Americium-241	5.75E-05	6.04E-06	1.44E-05	1.51E-06	1.67E-07	3.33E-08	4.17E-08	8.33E-09
Cesium-137+D	3.81E-03	7.44E-04	9.52E-04	1.86E-04	9.51E-04	1.99E-04	2.38E-04	4.97E-05

RDD Table to use footnotes "RDD scenario risks Dublin ver 2.xls"

1 SPRG risk for Resident outside with California urban local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California urban local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California urban local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California urban other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California urban other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California urban other principal arterial (PEFm). 10 SPRG risk for Resident outside with California urban minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California urban minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California urban minor arterial (PEFm). 13 SPRG risk for Resident outside with California urban collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California urban collector (PEFm). 15 SPRG risk for Indoor Worker outside with California urban collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEF. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEFw. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D.

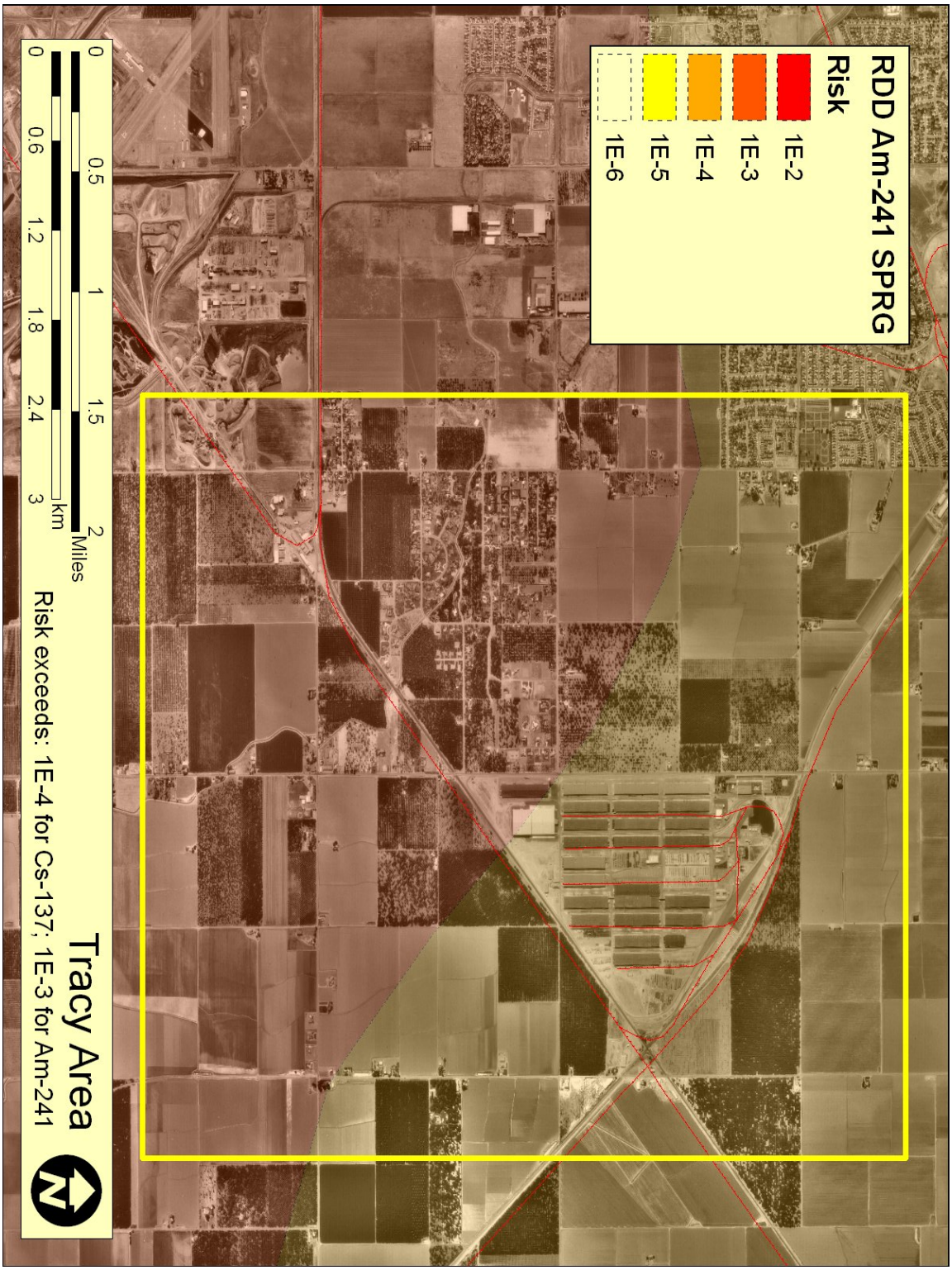
	Soil Volume (g)	Ground Plane (cm^2)	
Am-241	2.76E-08	1.90E-08	
Cs-137+D	2.55E-06	5.09E-07	For these 4 scenarios we had to assume that the slope factors
Sr-90+D	1.96E-08	1.71E-08	were reasonably close to ratio concentrations of different units.


Dublin
1999 FUNCTIONAL CLASSIFICATION SYSTEM
URBAN
INTERSTATE
OTHER FWY OR EXPWY
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
COLLECTOR
RURAL
INTERSTATE
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
MAJOR COLLECTOR
MINOR COLLECTOR
1999
DIANA LN
FREDERIKSEN LN
BURNHAM WY
TAMARACK DR
BRIGHTON
DUBLIN HS
LANCASTER RD
PENN DR
EDEN ST
HICKORY LN
STAGECOACH RD
QUARTZ CIR
CREEK
7200
7500

Suburban (Dublin) "Calculated Results ver6.xls"

Land Use/ building use		Sub Area extent	Total Extent	Technology Selected	Unit Cost	Rate (sq ft/hr)	Variable costs ($/sq ft) *	DF	Total Costs	Unit Manhours	Total Manhours	Unit Solid Waste	Total Solid Waste	Unit Liquid Waste	Total Liquid Waste
Building exteriors	Original	4778099		Hotwash	$3,000	350	$4	4	$17,204,156	2	27303		0	3	14334297
	Post Cleanup														
Res. Interiors (non-evac)	Original	6601248		Hotwash w/ chelator	$3,000	350	$4	8	$26,407,992	2	37721		0	3	19803744
	Post Cleanup														
Ind. Interiors (non-evac)	Original	760341		Steam vacuum cleaning	$10,000	150	$14	20	$10,274,604	3	15207	2	1520682		0
	Post Cleanup														
Local Parks	Original	238786		Media blasting	$12,000	100	$5	100	$1,110,416	3	7164	0.75 / pass	#VALUE!		0
	Post Cleanup														
Lawns	Original	3611453		Deep plowing	$50,000	43560	$0	10	$52,487	1	83	0	0		0
	Post Cleanup														
Local streets	Original		1638008	Media blasting	$12,000	100	$5	100	$7,546,837	3	49140	0.75 / pass	#VALUE!		0
	Post Cleanup														
Highways	Original			ALARA 1146 Strippable coating	$0	133	$5	7	$0	3	0	0.25 / coat	#VALUE!		0
	Post Cleanup														
Drives and parking lots	Original			Paving (new road)	$500,000	244	$10	na	$8,177,463	20	66242	95	76774630		0
	Post Cleanup	808154													
Totals	Original								$70,773,955			#VALUE!		34138041	
	Post Cleanup														

	one neighborhood area	all area in plume	select decon method from dropdown	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet (area*$/area)	automatic from tech specs sheet	(area/sq ft/hr)* manpower	automatic from tech specs sheet	area * unit solid waste	automatic from tech specs sheet	area * unit liquid waste


RDD Am-241 SPRG
Risk
1E-2
1E-3
1E-4
1E-5
1E-6
0
0.5
1
1.5
2
Miles
0
0.6
1.2
1.8
2.4
3
km
Tracy Area
Risk exceeds: 1E-4 for Cs-137; 1E-3 for Am-241

RDD Table to use "RDD scenario risks Tracy ver 2.xls"

Baseline Risk Assessment Table: RDD Tracy Rural

Pre-remedial Concentrations Outside; Americium 0.08 pCi/cm2 Cesium-137+D 8 pCi/cm2

Pre-remedial Risk from Outside Concentrations

	Risk if Residential Rural local Rd [1]	Risk if Outdoor Worker Rural local Rd [2]	Risk if Indoor Worker Rural local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Americium-241	5.71E-05	9.79E-05	4.60E-05	1.25E-04	8.20E-05	5.80E-05
Cesium-137+D	2.00E-04	1.16E-04	1.17E-04	1.17E-04	2.01E-04	1.17E-04

	Risk if Residential Rural Other Principal Arterial [7]	Risk if Outdoor Worker Rural Other Principal Arterial [8]	Risk if Indoor Worker Rural Other Principal Arterial [9]	Risk if Residential Rural Minor Arterial [10]	Risk if Outdoor Worker Rural Minor Arterial [11]	Risk if Indoor Worker Rural Minor Arterial [12]
Americium-241	8.23E-02	1.70E-01	7.55E-02	3.56E-03	7.34E-03	3.27E-03
Cesium-137+D	2.77E-03	5.71E-03	2.60E-03	3.09E-04	3.54E-04	2.22E-04

	Risk if Residential Rural Major Collector [13]	Risk if Outdoor Worker Rural Major Collector [14]	Risk if Indoor Worker Rural Major Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]	Fixed 3-D Risk Inside Unevacuated Bldg Agricultural [35]	Fixed 3-D Risk Inside Evacuated Bldg Agricultural [36]
Americium-241	7.92E-04	1.61E-03	7.21E-04	1.72E-08	8.88E-09	3.94E-09	1.77E-07	4.43E-08
Cesium-137+D	2.23E-04	1.66E-04	1.39E-04	2.82E-05	1.53E-05	6.78E-06	2.55E-04	6.37E-05

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]	Risk if Agriculture Land (Subsistence Farmer) [31]	Risk if Agriculture Land (Typical Farmer) [32]	Dust Risk Inside Unevacuated Bldg Agricultural [33]	Dust Risk Inside Evacuated Bldg Agricultural [34]
Americium-241	3.90E-12	4.28E-08	1.40E-08	6.67E-09	6.06E-06	6.06E-06	5.63E-05	1.41E-05
Cesium-137+D	1.36E-06	1.34E-04	7.08E-05	3.16E-05	6.67E-03	6.45E-03	9.58E-04	2.40E-04

Pre-remedial Risk from Inside Concentrations

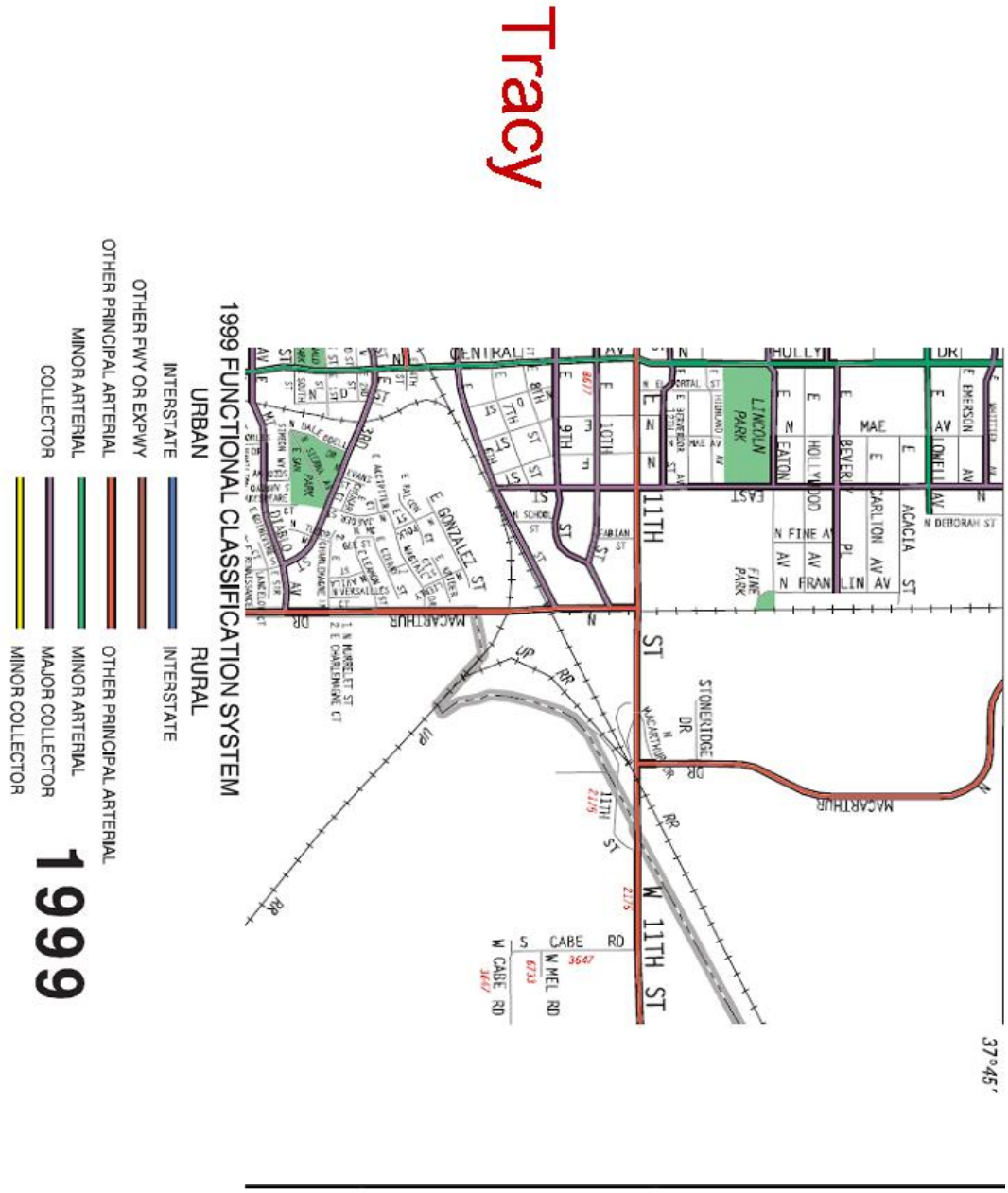
	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Comm/Ind [28]	Risk from Fixed 3-D if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if if Inside Evacuated Bldg Comm/Ind [30]
Americium-241	4.60E-05	4.83E-06	1.15E-05	1.21E-06	1.33E-07	2.67E-08	3.33E-08	6.67E-09
Cesium-137+D	8.47E-04	1.65E-04	2.12E-04	4.13E-05	2.11E-04	4.42E-05	5.28E-05	1.10E-05

RDD Table to use footnotes "RDD scenario risks Tracy ver 2.xls"

1 SPRG risk for Resident outside with California Rural local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California Rural local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California Rural local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California Rural other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California Rural other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California Rural other principal arterial (PEFm). 10 SPRG risk for Resident outside with California Rural minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California Rural minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California Rural minor arterial (PEFm). 13 SPRG risk for Resident outside with California Rural major collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California Rural major collector (PEFm). 15 SPRG risk for Indoor Worker outside with California Rural major collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEF. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEF. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG fixed 3-D. 28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG fixed 3-D. 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 31 PRG risk Agriculture Default. 32 PRG risk Agricultural Typical Farmer using contaminated plant fractions from Superfund SDEF. 33 BPRG dust risk for Unevacuated Agricultural. 34 BPRG dust risk for Evacuated Agricultural. 35 BPRG Fixed 3-D risk for Unevacuated Agricultural. 36 BPRG Fixed 3-D risk for Evacuated Agricultural.

	Soil Volume (g)	Ground Plane (cm^2)
Am-241	2.76E-08	1.90E-08
Cs-137+D	2.55E-06	5.09E-07
Sr-90+D	1.96E-08	1.71E-08

For these 6 scenarios we had to assume that the slope factors were reasonably close to ratio concentrations of different units.


Tracy
1999 FUNCTIONAL CLASSIFICATION SYSTEM
URBAN
INTERSTATE
OTHER FWY OR EXPWY
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
COLLECTOR
RURAL
INTERSTATE
OTHER PRINCIPAL ARTERIAL
MINOR ARTERIAL
MAJOR COLLECTOR
MINOR COLLECTOR
1999
11TH ST
W 11TH ST
MACARTHUR DR
CENTRAL AV
E GONZALEZ ST
LINCOLN PARK
FINE PARK
S CABE RD
W CABE RD
W MEL RD
37°45'

Rural (Tracy) "Calculated Results ver6.xls"

Land Use/ building use		Sub Area extent (ft²)	Total Extent (ft²)	Technology Selected	Fixed costs ($/unit)	Rate (sq ft/hr)	Variable costs ($/sq ft) *	DF	Total Costs	Manpower / unit	Total Manhours	Unit Solid Waste (#'s/ft^2)	Total Solid Waste (pounds)	Unit Liquid Waste (#'s/ft^2)	Total Liquid Waste (pounds)
Building exteriors	Original	9663537	1	Hotwash	$3,000	350	$4	4	$34,791,733	2	55220		0	3	28990611
	Post Cleanup														
Res. Interiors	Original	4488841	1	ALARA 1146 Strippable coating	$0	133	$5	7	$21,770,879	3	101252	0.25 / coat	#VALUE!		0
	Post Cleanup														
Farmer Interiors	Original	6414429	1	Media blasting	$12,000	100	$5	100	$29,518,373	3	192433	0.75 / pass	#VALUE!		0
	Post Cleanup														
Ind. Interiors	Original	167271	1	Concrete scabbling (1/4" deep)	$12,000	200	$2	200	$346,542	3	2509	3 / pass	#VALUE!		0
	Post Cleanup														
Agriculture	Original	191054964	1	Paving (new road)	$500,000	244	$10	na	$1,815,522,158	20	15660243	95	1.81E+10		0
	Post Cleanup														
National Parks	Original	1	1	Soil excavation (skim)	$50,000	13068	$0	10	$50,000	2	0	18.37	18.37		0
	Post Cleanup														
Lawns	Original	2600237	1	Deep plowing	$50,000	43560	$0	10	$51,791	1	60	0	0		0
	Post Cleanup														
Local streets	Original	10602505	1	Media blasting	$12,000	100	$5	100	$48,783,523	3	318075	0.75 / pass	#VALUE!		0
	Post Cleanup														
Highways	Original	1	1	ALARA 1146 Strippable coating	$0	133	$5	7	$5	3	0	0.25 / coat	#VALUE!		0
	Post Cleanup														
Drives and parking lots	Original	589952	1	Media blasting	$12,000	100	$5	100	$2,725,779	3	17699	0.75 / pass	#VALUE!		0
	Post Cleanup														
Totals	Original								$1,953,560,793				#VALUE!		28990611
	Post Cleanup														

	one neighborhood area	all area in plume	select decon method from dropdown	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet	automatic from tech specs sheet	fixed cost + (area*$/area)	automatic from tech specs sheet	(area/sq ft/hr)* manpower	automatic from tech specs sheet	area * unit solid waste	automatic from tech specs sheet	area * unit liquid waste

Scenario 2.
Nuclear Detonation –10-kiloton Improvised Nuclear Device

Background

At 9:00 a.m. on November 1, 2006, the IND is loaded into the delivery van. At about 11:15 a.m., the vehicle exits the freeway and when in place in an undisclosed location in San Francisco, the passenger detonates the 10-kiloton nuclear device. Most buildings within 1,000 meters (~ 3,200 feet) of the detonation are severely damaged. Injuries from flying debris (missiles) may occur out to 6 kilometers (~ 3.7 miles). An Electromagnetic Pulse (EMP) damages many electronic devices within about 5 kilometers (~ 3 miles). A mushroom cloud rises above the city and begins to drift east-northeast.

The exposure to large doses of radiation will produce an increased long-term risk of cancer for the exposed people. These cases will need to be monitored and treated for many years.

Assumptions –

• The explosion produces a nuclear yield of 10-kilotons from a device that uses uranium as the fissile material.

• The prompt effects of the detonation cover an approximately circular area of devastation and the degree of destruction tapers off with increasing distance from ground zero.

• The device is detonated at ground level.

• Immediate protective actions will greatly reduce fatalities and injuries from the exposure to the radiation.

• The weather is clear – there is a light haze and a light breeze, with no snow or cloud cover.

Human Impact

- 229,900 fatalities
- 317,400 injuries
- Extensive environmental contamination
- Evacuation of 1.16 million to 2.11 million persons during early phase.
- Relocation of 1.22 million persons in first year PAG (2 rem/yr) relocation zone.
- Relocation of 521,000 persons in second year PAG (500 mrem/yr) relocation zone.
- 1 million+ self-evacuate from major urban areas
- 3.68 million individuals residing in the area exposed to over EPA de minimis levels (1×10^{-6}) and 2.52 million exposed to over EPA health based levels (1×10^{-4}) with long-lived contaminants.

Infrastructure Damage

Total within radius of 0.5 to 3 miles

Economic Impact
Hundreds of billions of dollars

Potential for Multiple Events
No

Recovery Timeline
Years

Contaminants of Concern
The initial detonation from a nuclear weapon will result in approximately 1,000 radionuclides. Most of these are very short-lived. In the late-phase, it is expected that 2 radionuclides will represent the majority of residual risk.

Cs-137 is a gamma emitter that will still pose a threat even if not inhaled or ingested.

Sr-90 is a beta emitter that primarily poses a health threat when inhaled or ingested.

Extent of Contamination

- 281 kilometers (175 miles) and 3,679 square kilometers (1,420 square miles) in first year PAG (2 rem) relocation zone.
- 87.9 kilometers (54.6 miles) and 444 square kilometers (171 square miles) in second year PAG (500 mrem/yr) relocation zone.
- 96.7 kilometers (60.1 miles) and 691 square kilometers (267 square miles) over 100 times EPA health based levels (1×10^{-2} cancer risk) for residential land use indoors in non evacuated areas. 631,000 persons in this area.
- 379 kilometers (235 miles) and 6,709 square kilometers (2,590 square miles) over 10 times the EPA health based levels (1×10^{-3} cancer risk) for residential land use indoors in non evacuated areas. 1.35 million persons in this area.
- 381 kilometers (237 miles) and 14,936 square kilometers (5,767 square miles) over EPA health based levels (1×10^{-4} cancer risk) for residential land use indoors in non evacuated areas. 1.80 million persons in this area.
- 387 kilometers (240 miles) and 42,377 square kilometers (16,362 square miles) over EPA de minimis levels (1×10^{-6} cancer risk) for residential land use indoors in non evacuated areas. 3.68 million persons in this area.

There are two main sources of the ionizing radiation that cause radiation induced injuries and fatalities. The first is the prompt radiation produced by the detonation itself and which, by arbitrary definition, occurs within the first minute after the detonation. The second is the radiation emitted by the radioactive fallout. Both of these, taken together, will hereafter be referred to simply as "radiation exposure."

Structural Damage –

Direct damage to structures in the area surrounding a nuclear detonation occurs due to air blast, ground shock, and thermal radiation. Ionizing radiation does not damage structures, although the presence of radioactive fallout may make buildings uninhabitable unless

decontamination takes place. The interaction geometry between the blast wave and the various surfaces of the structure plays an important role in blast damage. Damage to structures is broadly categorized according to whether the damage is a result of the maximum pressure of the shock wave or the duration of the pressure wave. Both effects are included in the calculations of the damage to structures. Various types of structures are considered, including wood frame houses; multi-story (MS) buildings with low-strength, quickly failing walls (LSQFW) and earthquake resistant designs (ERD); railroad girder bridges; and highway girder bridges.

The construction practices and building designs of a given local area are extremely difficult to account for in a calculation of this type and vary greatly from one location to the next. If these factors were accounted for, they would produce a result that is site specific and less generally applicable to other locations.

Prompt Radiation and Fallout –

Radiation casualties following a nuclear detonation may be caused by prompt nuclear radiation or by radiation from the radioactive fallout, or both. In this calculation, prompt radiation is defined as that occurring within the first minute after detonation and includes neutrons, x-rays, and gamma rays originating from the nuclear reactions producing the yield in the nuclear device and the radioactive decay that the resulting fission "daughter" produces during this time.

A nuclear, surface burst will produce significant downwind radioactive fallout, up to about 160 kilometers (100 miles). This fallout is due to the large quantity of material (e.g., dirt, asphalt, concrete, steel) close to the device when it detonates. Much of this material is vaporized in the detonation and is carried up by the rising fireball. The fireball mixes the radioactive fission products and this vaporized material. The fireball cools as it rises, and the vaporized material and the fission products coalesce to form particles. These particles are carried off and dispersed downwind where the larger, heavier particles fall to the ground first. This dispersal is a complicated process that depends on many factors including the amount of heat energy in the fireball, the amount and composition of the vaporized material, and the size of the particles formed, as well as the weather conditions. The radioactive fission products in the fallout may emit alpha, beta, or gamma rays or combinations of these. Neutron radiation is predominately produced in the prompt phase and is not a significant component of the fallout radioactivity.

Less local fallout is produced by a nuclear detonation where the fireball does not touch the ground. The yield of a device, and thus the quantity of fission products produced, is unaffected by the height of detonation. However, since there is much less surrounding material to be vaporized, there is less material with which the fission products can coalesce. Therefore, smaller particles are formed and carried much further (essentially around the world) by the air currents. Since this radiation is dispersed over a much larger area, it poses much less danger in the local area (tens to hundreds of miles) immediately downwind from the detonation.

General Health Physics Rules

• After the prompt radiation has subsided, the external gamma radiation from fission products deposited on the ground is the most significant health hazard and is expressed as whole-body dose. There will be some beta radiation skin exposure, but in most cases this is not biologically significant.

• The dose from the detonation-produced airborne debris cloud as it passes by is negligible.

• Radioactive decay can be characterized by a simple function of time. The approximate rule is that for every sevenfold increase in time after the explosion, the dose rate decreases by a factor of ten. For example, 1 week (7 days) after the detonation, the dose rate from the fallout on the ground will be 1/10th its value on the day of the detonation; 7 weeks later, it will be 1/100th.

Recovery/Remediation:

Decontamination/Cleanup: Approximately 14,000 square kilometers (5,000 square miles) are contaminated to above health-based levels, including urban, suburban, rural, recreational, industrial, and agricultural areas. Expected radiation levels will limit the total time workers can spend higher radiation portions in the affected area, quickly leading to a shortage of willing, qualified, and trained workers. When a worker reaches this limit, he/she must be rotated to a job where no dose is received, or sent home. The volume of contaminated material that will be removed will overwhelm the national hazardous waste disposal facilities and will severely challenge the Nation's ability to transport the material. This effort will be the most expensive and time-consuming part of recovery and will likely cost many billions of dollars and take many years.

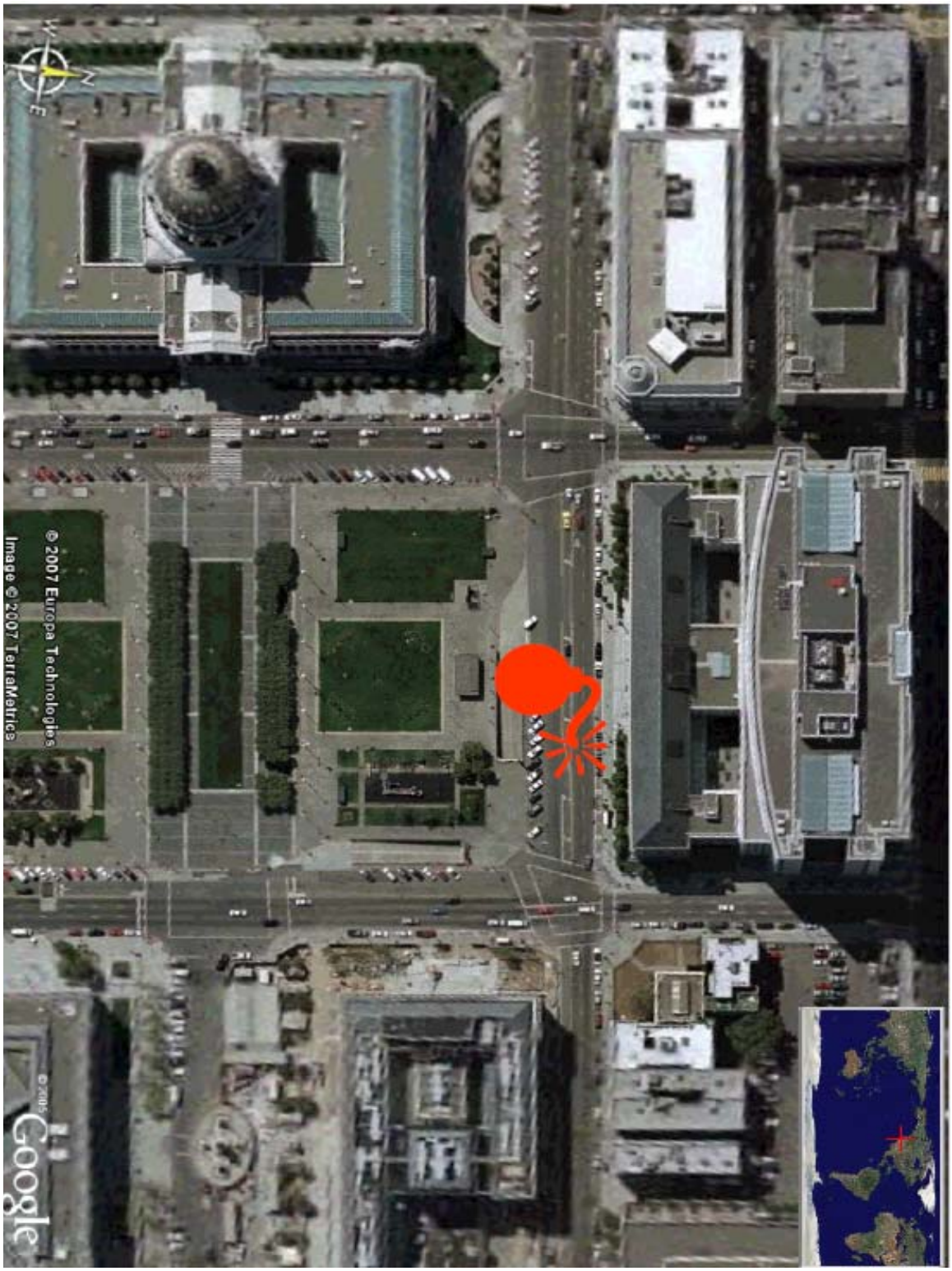
Site Restoration: A large area centered on ground zero will be destroyed. There will be varying degrees of damage in an approximately 100-square-kilometer (~ 40-square-mile) area. Some degree of decontamination will be required in a very large area that will have to be determined by the authorities. They will have to weigh the costs of the cleanup against the political realities of the situation.

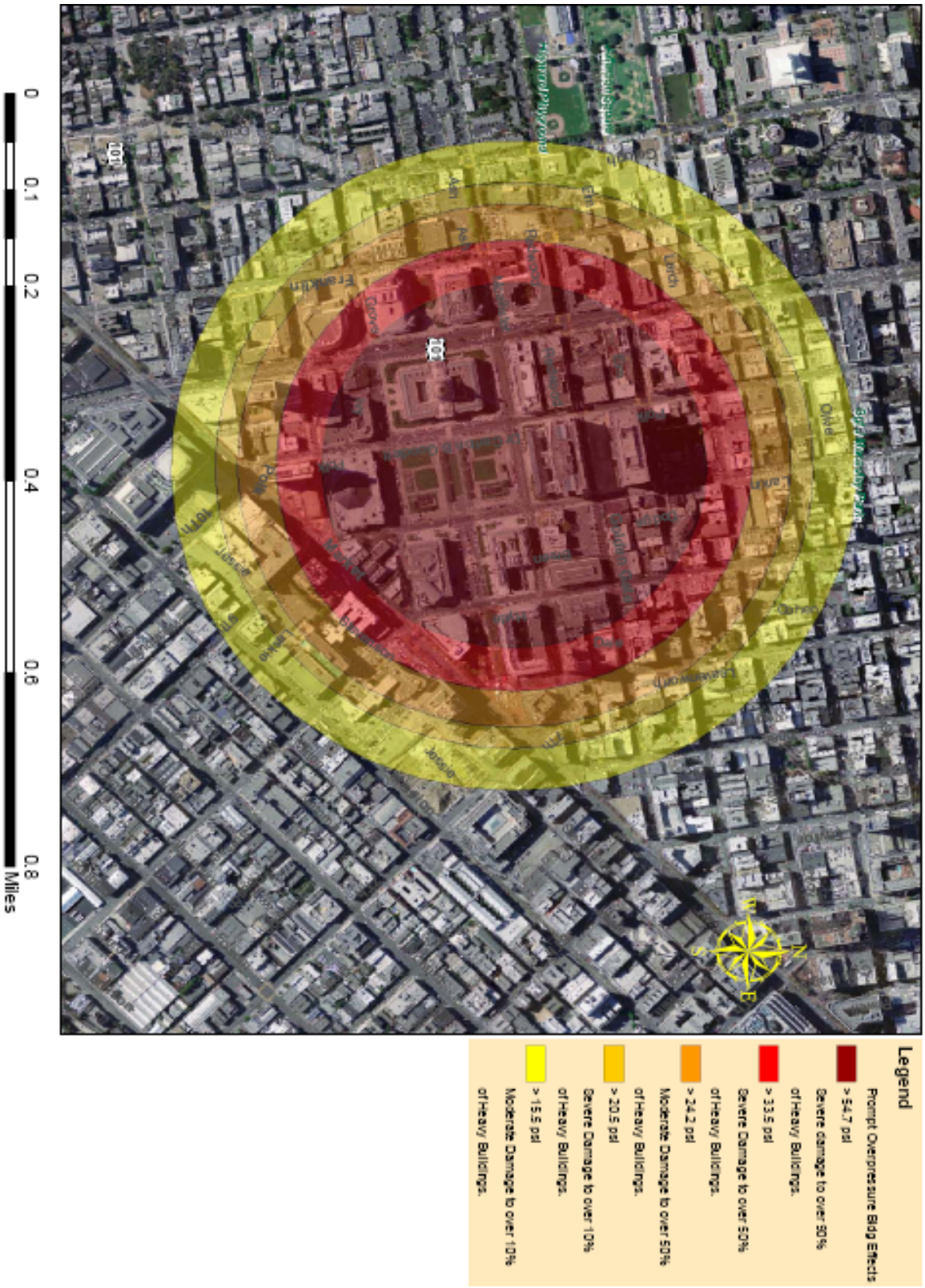
Response Actions in Early and Intermediate Phases

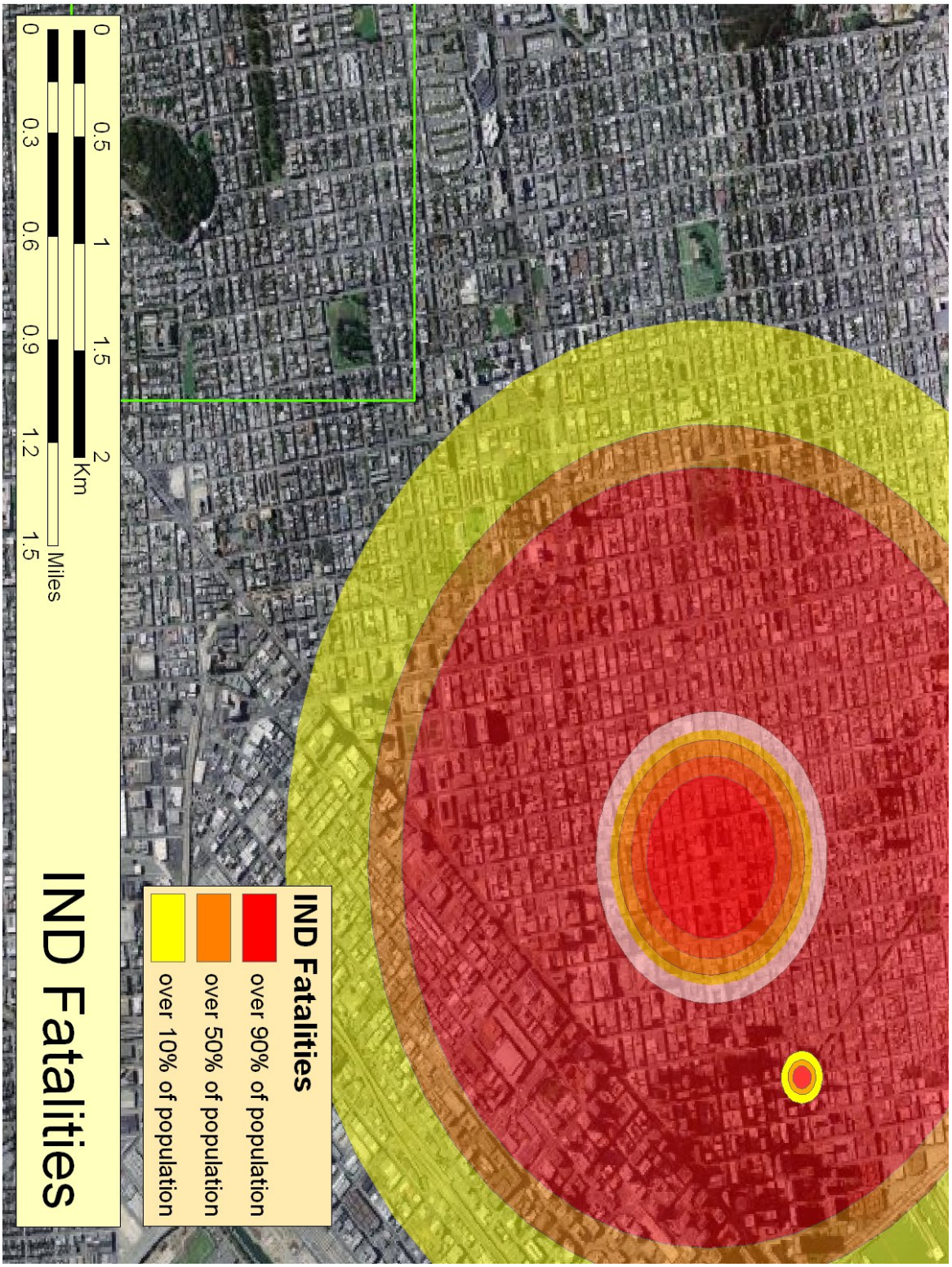
During the early and most likely the intermediate phase to return critical infrastructure and other areas to reuse before the onset of late-phase effects. The effects of these early and intermediate were not included in this exercise.

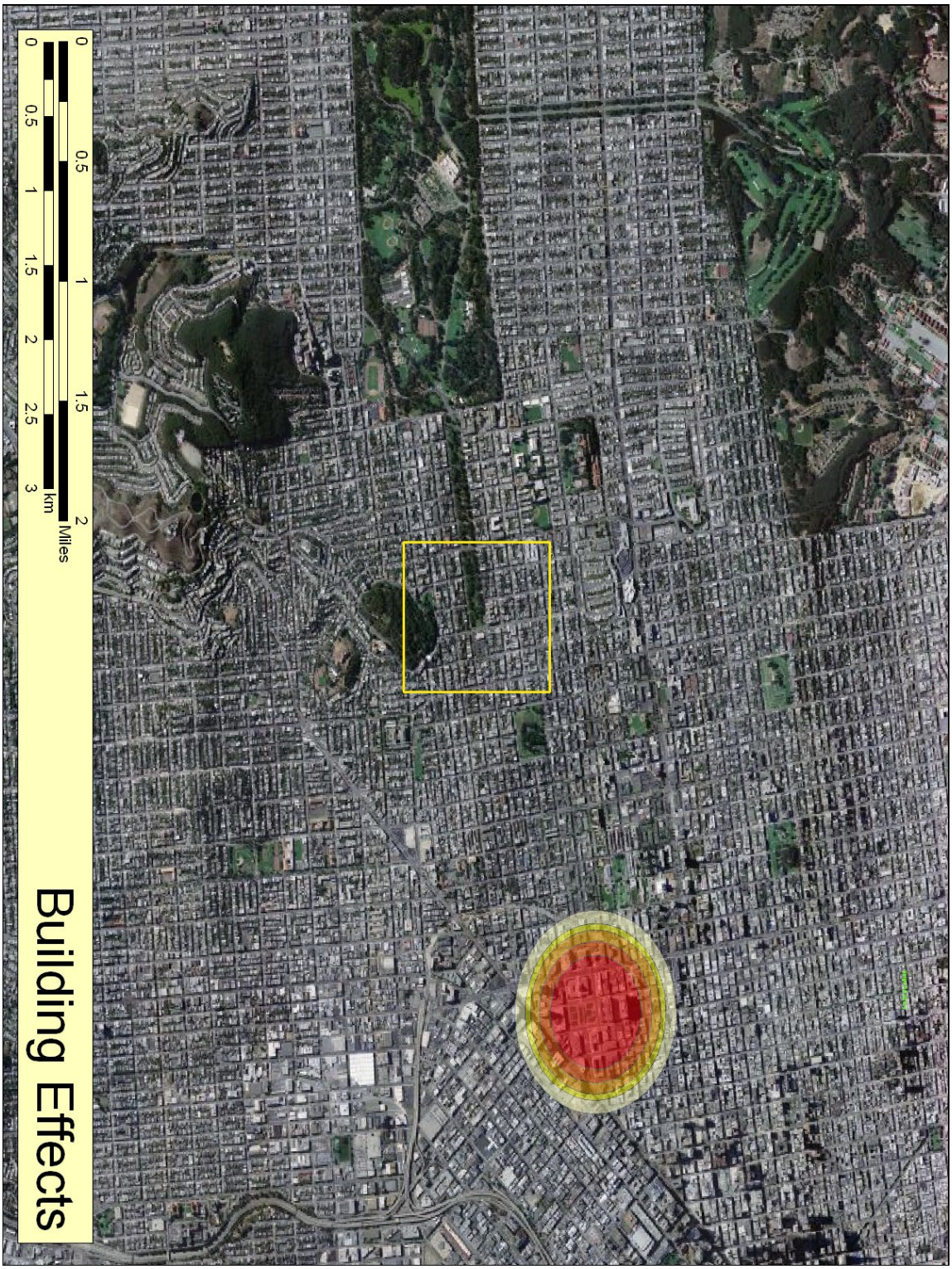
The following resource maps included here were used in the TTX:

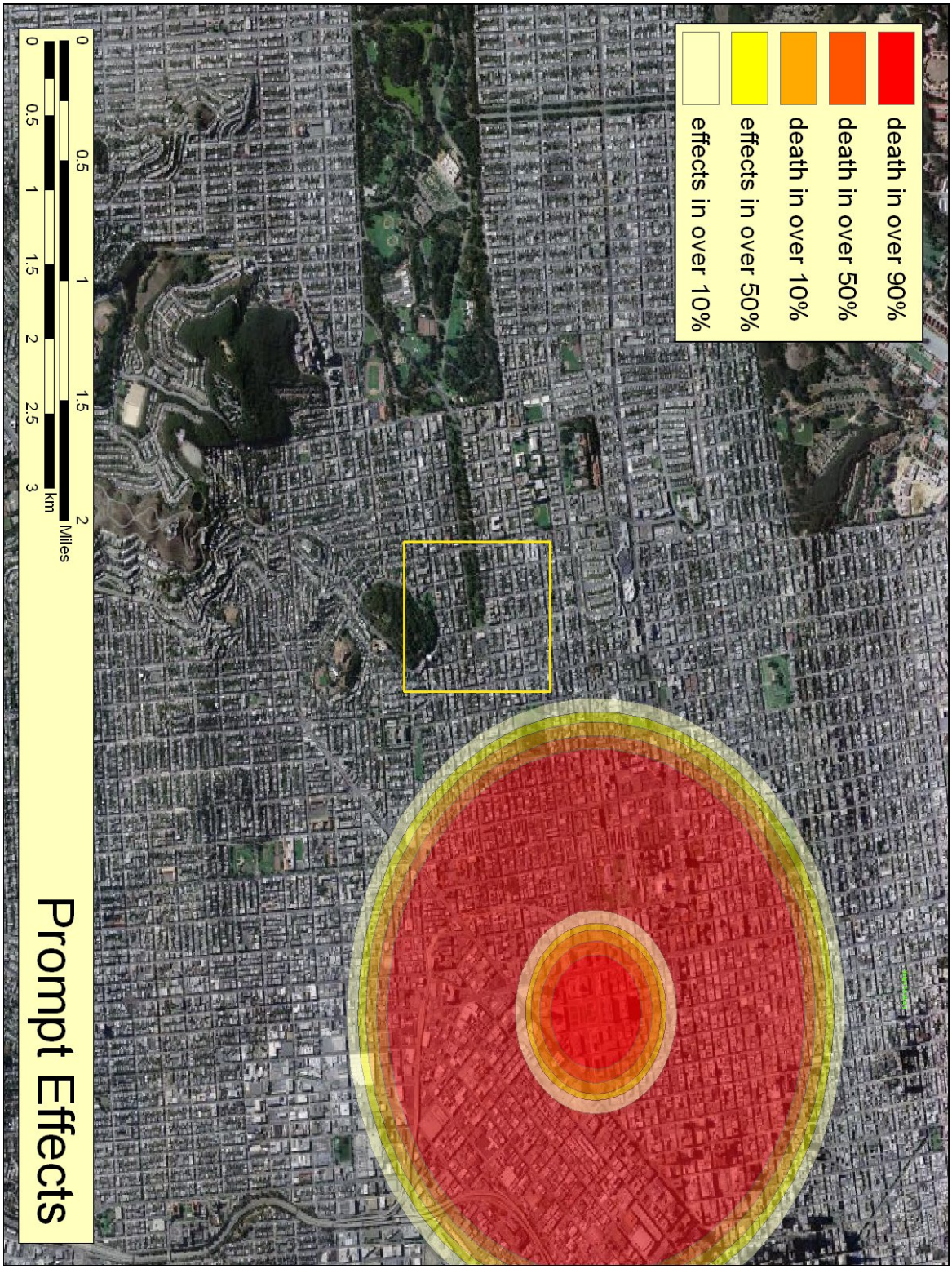
1. IND detonation location
2. Prompt overpressure building effects
3. IND Fatalities *(smaller circles represent RDD Fatalities)*
4. Building Effects
5. Prompt Effects
6. Acute Effects
7. IND Relocation (1st year)
8. IND Relocation (1st year)
9. IND Relocation (1st year)
10. IND Relocation (1st year)
11. IND Relocation (1st year)
12. IND Relocation (2nd year)
13. IND Relocation (5th year)
14. Cesium settled dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads.
15. Strontium settled dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads
16. Cesium multi-state dust contamination in the outdoors assuming an urban/suburban residential scenario with local roads.

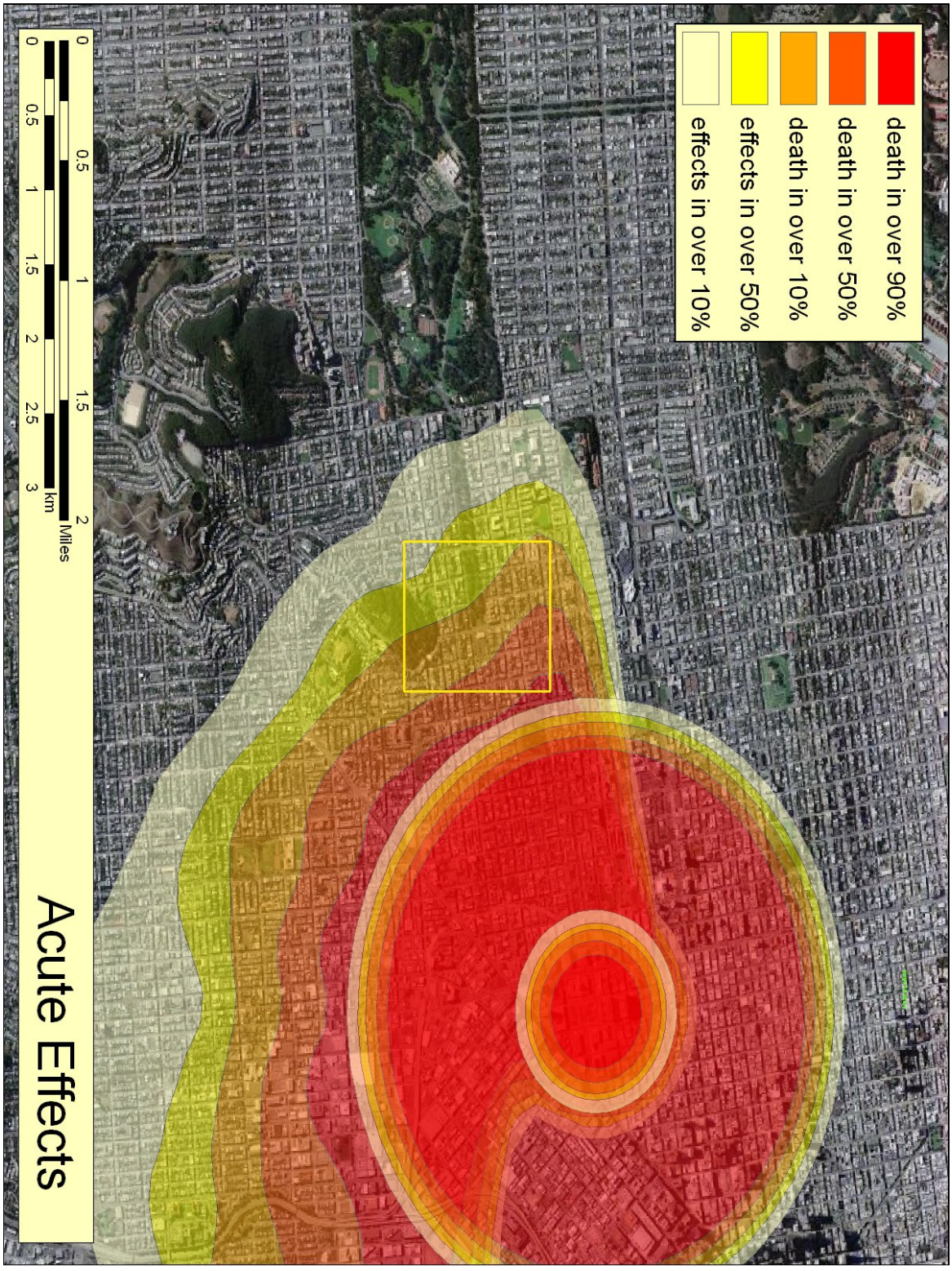

© 2007 Europa Technologies
Image © 2007 TerraMetrics
Google

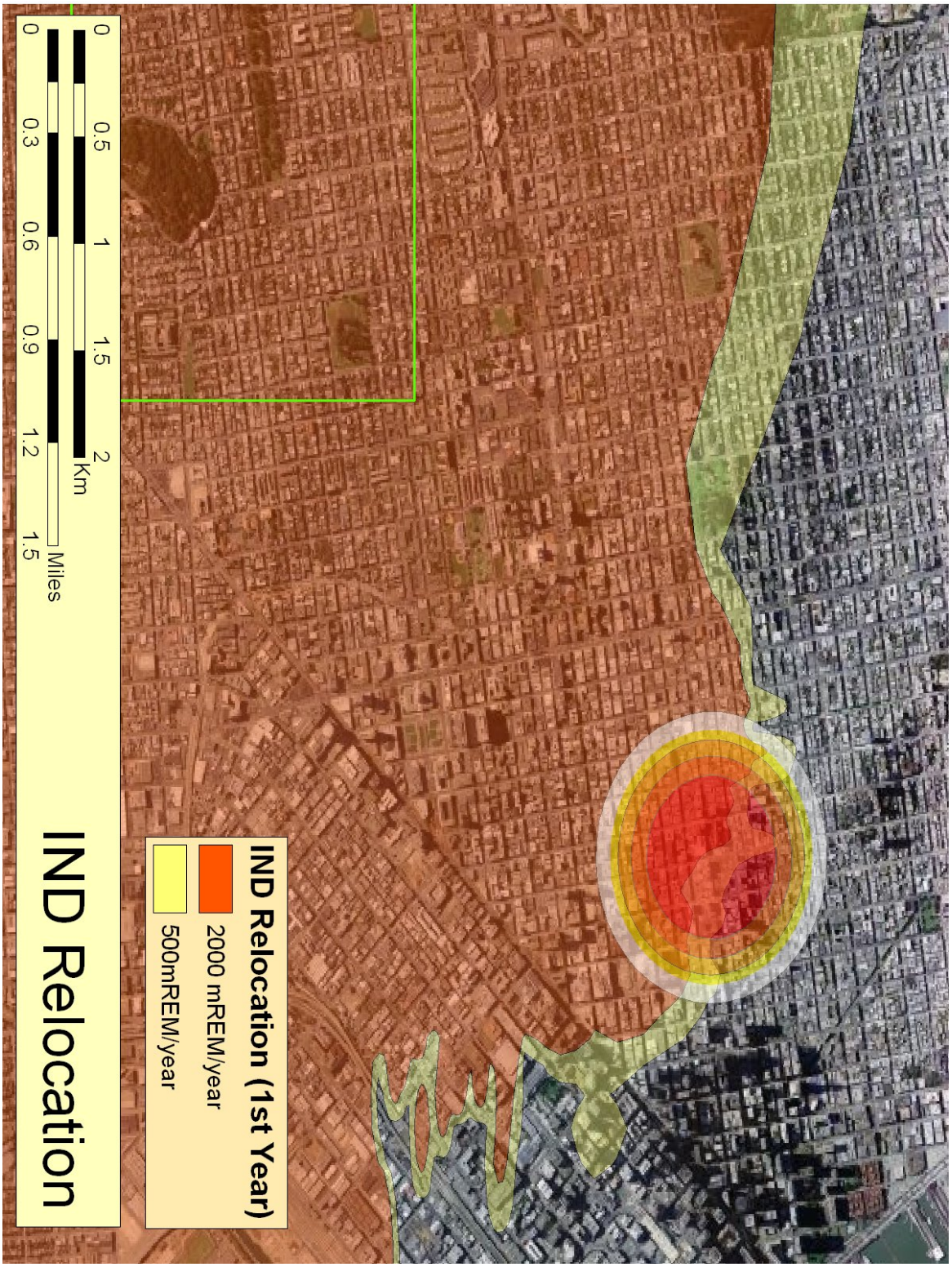

0
0.1
0.2
0.4
0.6
0.8
Miles
N
W
E
S
Legend
Prompt Overpressure Bldg Effects
> 54.7 psi
Severe damage to over 50% of heavy Buildings.
> 33.5 psi
Severe Damage to over 50% of heavy Buildings.
> 24.2 psi
Moderate Damage to over 50% of heavy Buildings.
> 20.5 psi
Severe Damage to over 10% of heavy Buildings.
> 15.5 psi
Moderate Damage to over 10% of heavy Buildings.

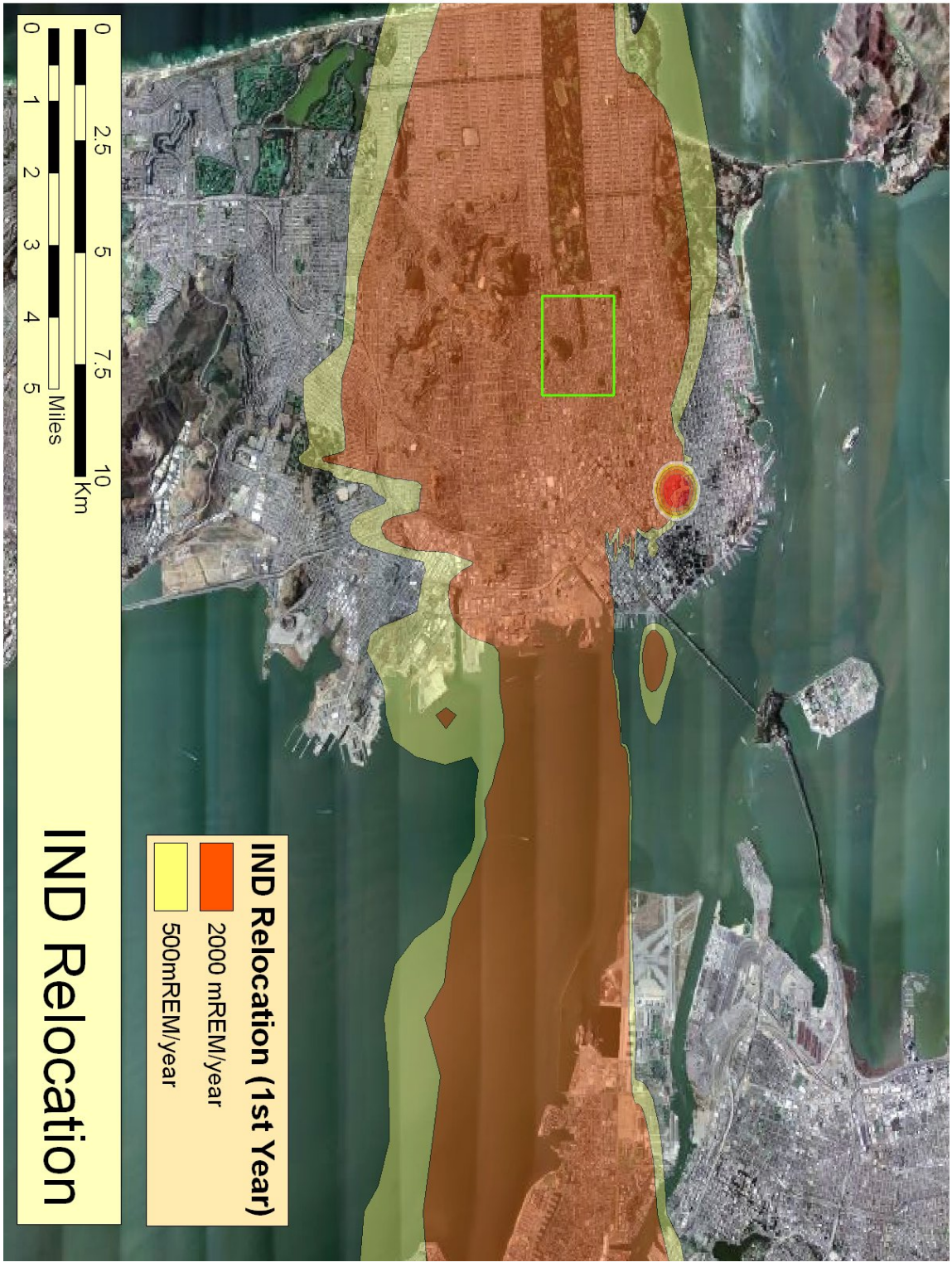

IND Fatalities
over 90% of population
over 50% of population
over 10% of population
0
0.5
1
1.5
2
Km
0
0.3
0.6
0.9
1.2
1.5
Miles
IND Fatalities

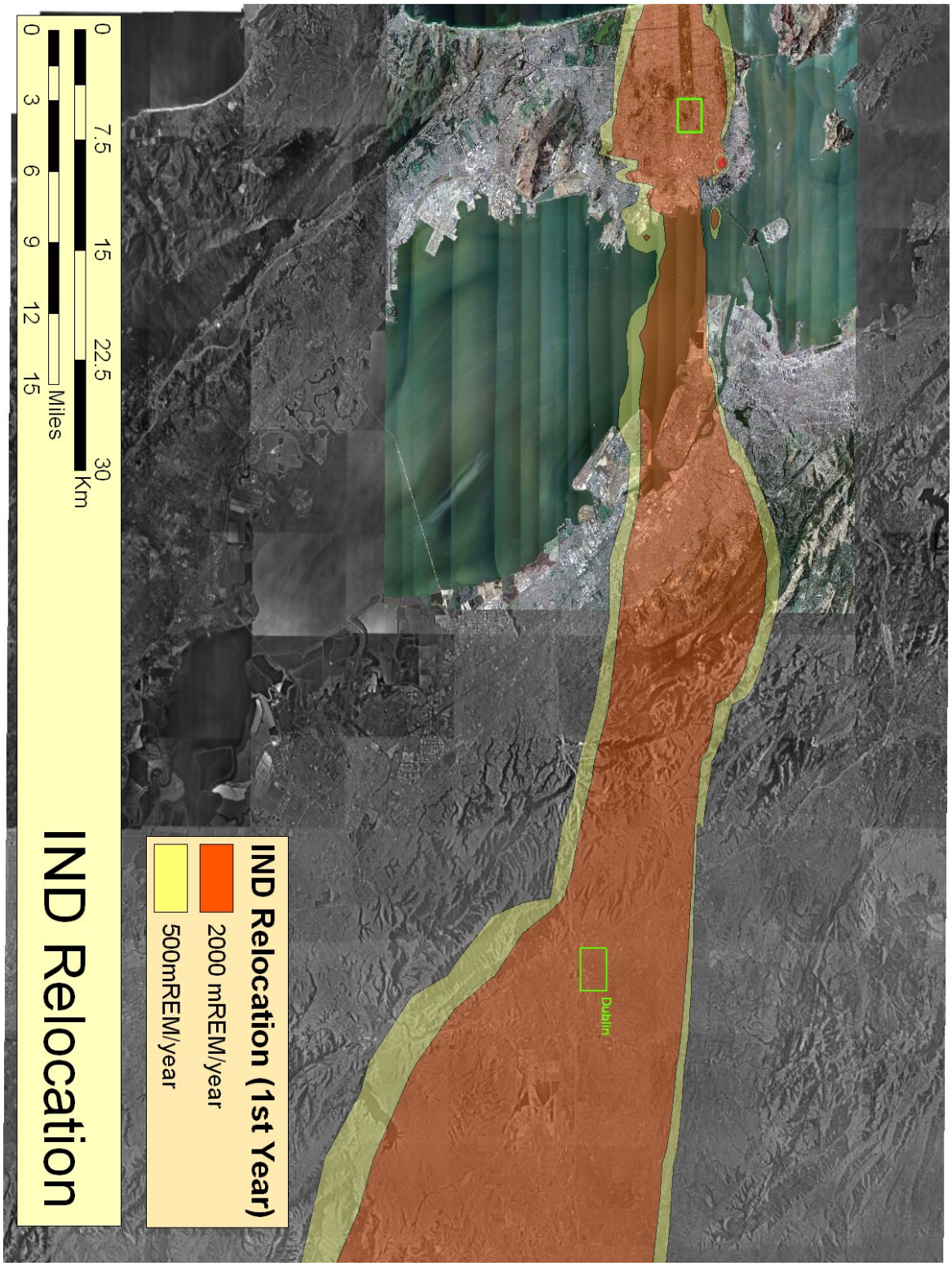

Building Effects
0
0.5
1
1.5
2
Miles
0
0.5
1
1.5
2
2.5
3
km

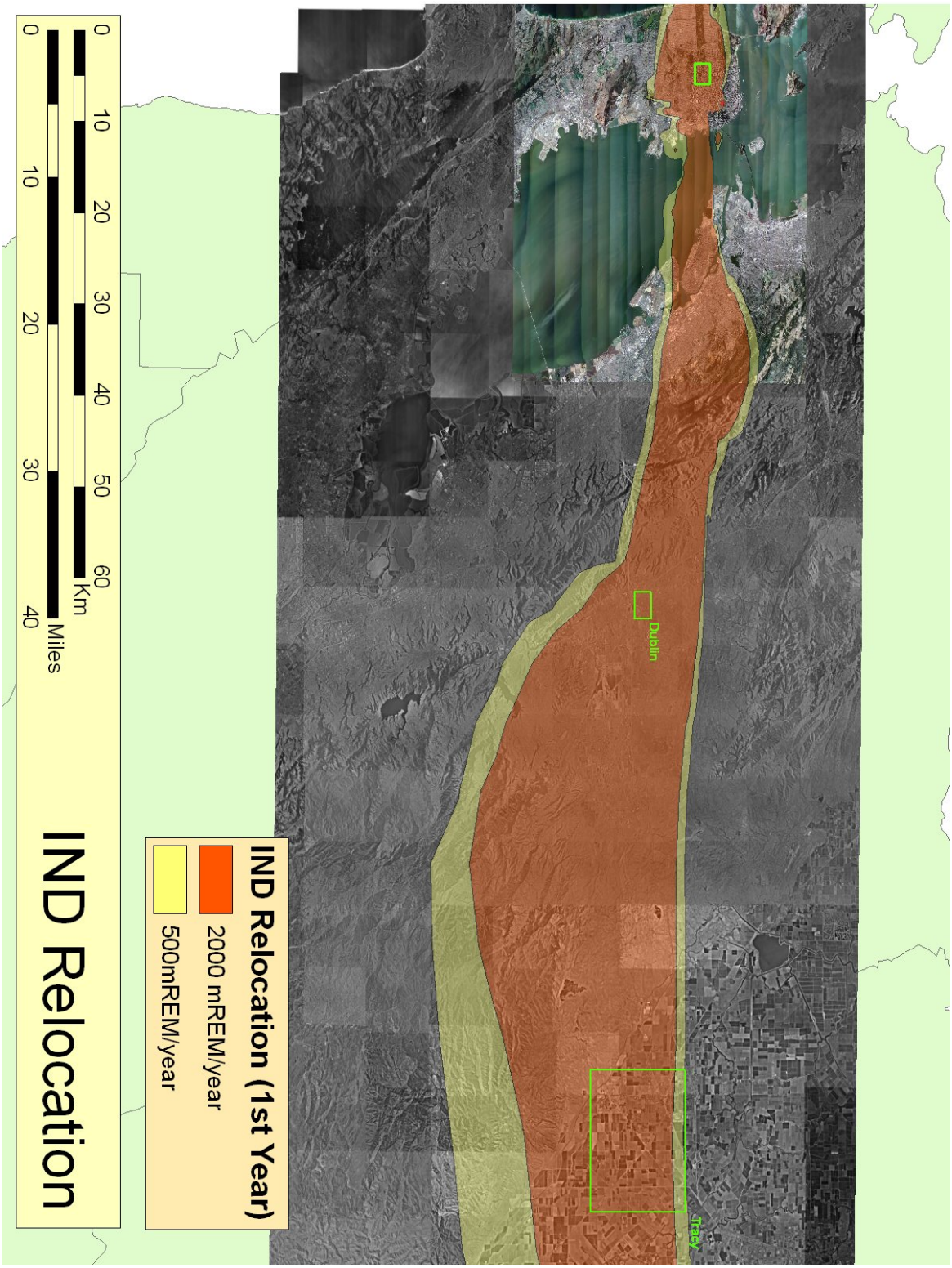

death in over 90%
death in over 50%
death in over 10%
effects in over 50%
effects in over 10%
0
0.5
1
1.5
2
Miles
0
0.5
1
1.5
2
2.5
3
km
Prompt Effects

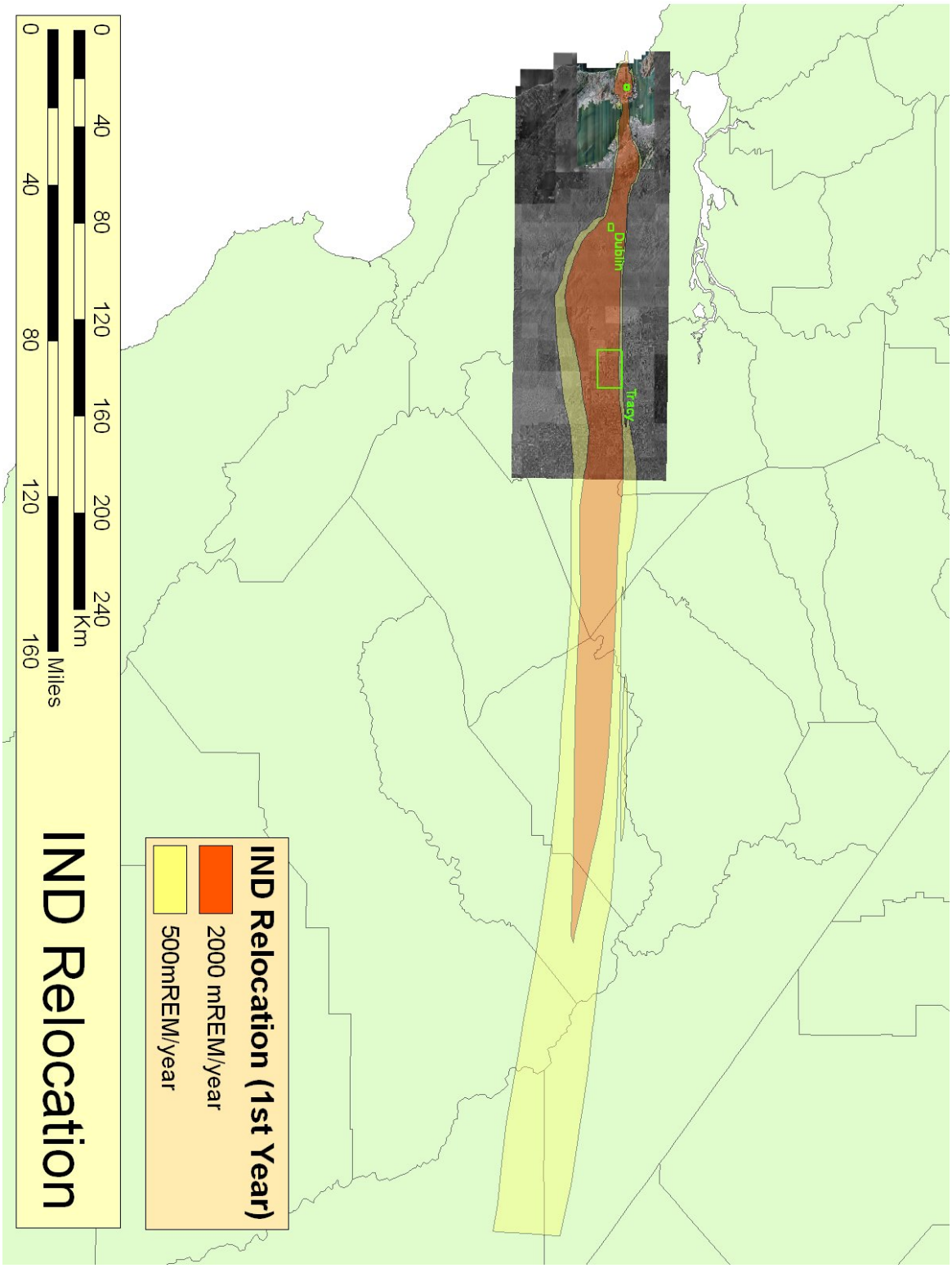

death in over 90%
death in over 50%
death in over 10%
effects in over 50%
effects in over 10%
0
0.5
1
1.5
2
Miles
0
0.5
1
1.5
2
2.5
3
km
Acute Effects

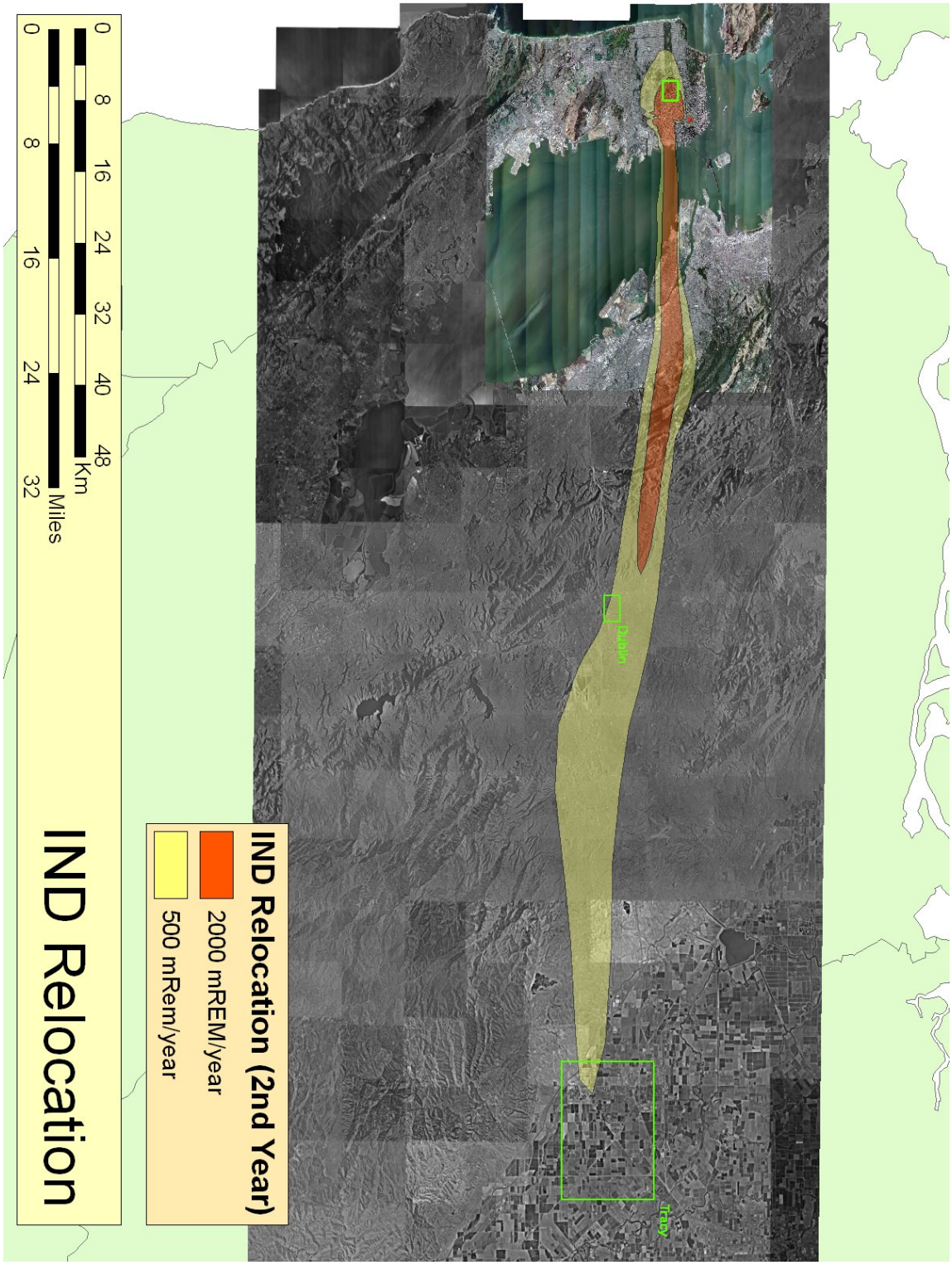

IND Relocation (1st Year)
2000 mREM/year
500mREM/year
0 0.5 1 1.5 2 Km
0 0.3 0.6 0.9 1.2 1.5 Miles
IND Relocation

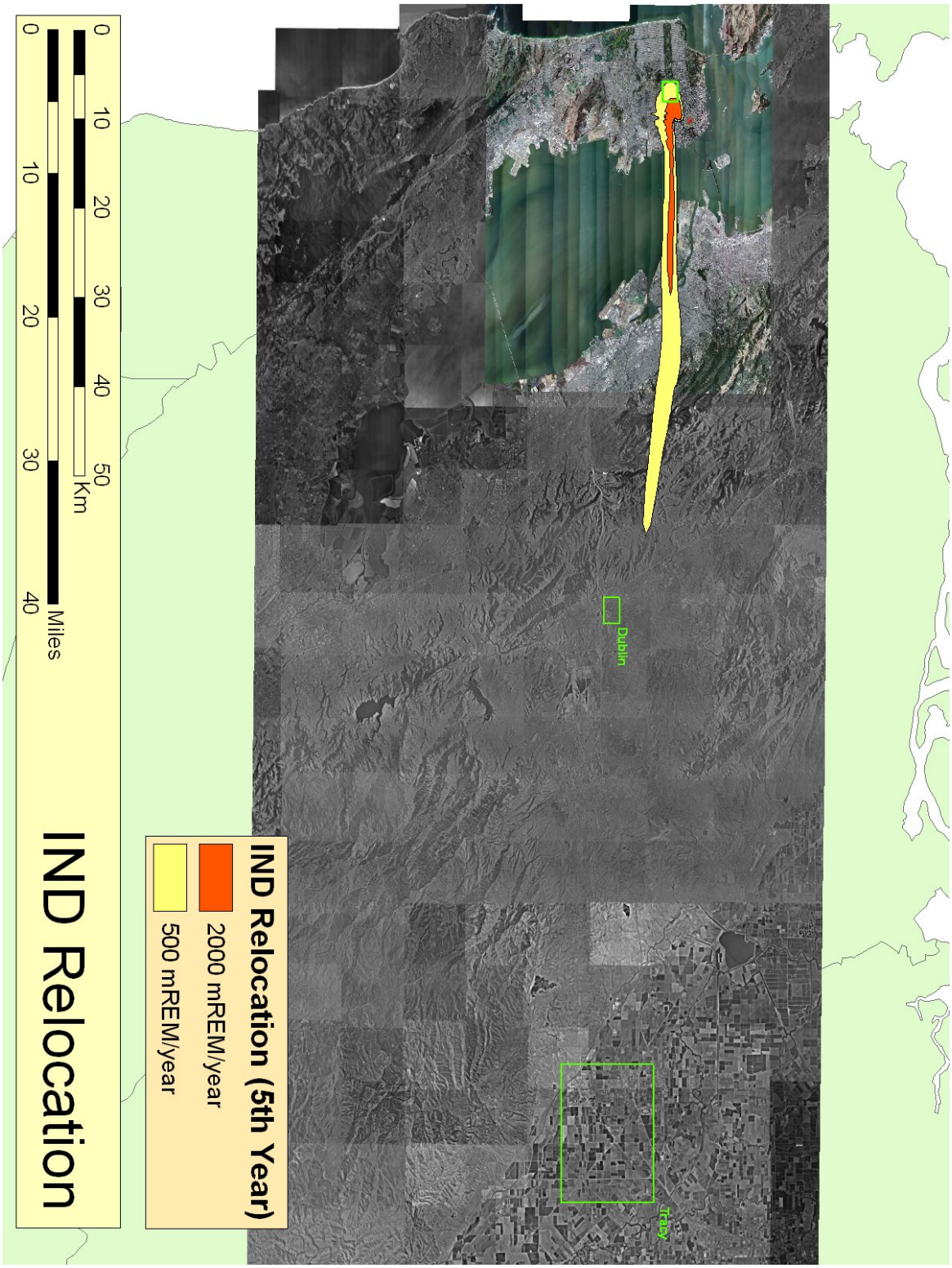

IND Relocation (1st Year)
2000 mREM/year
500mREM/year
0
2.5
5
7.5
10
Km
0
1
2
3
4
5
Miles
IND Relocation

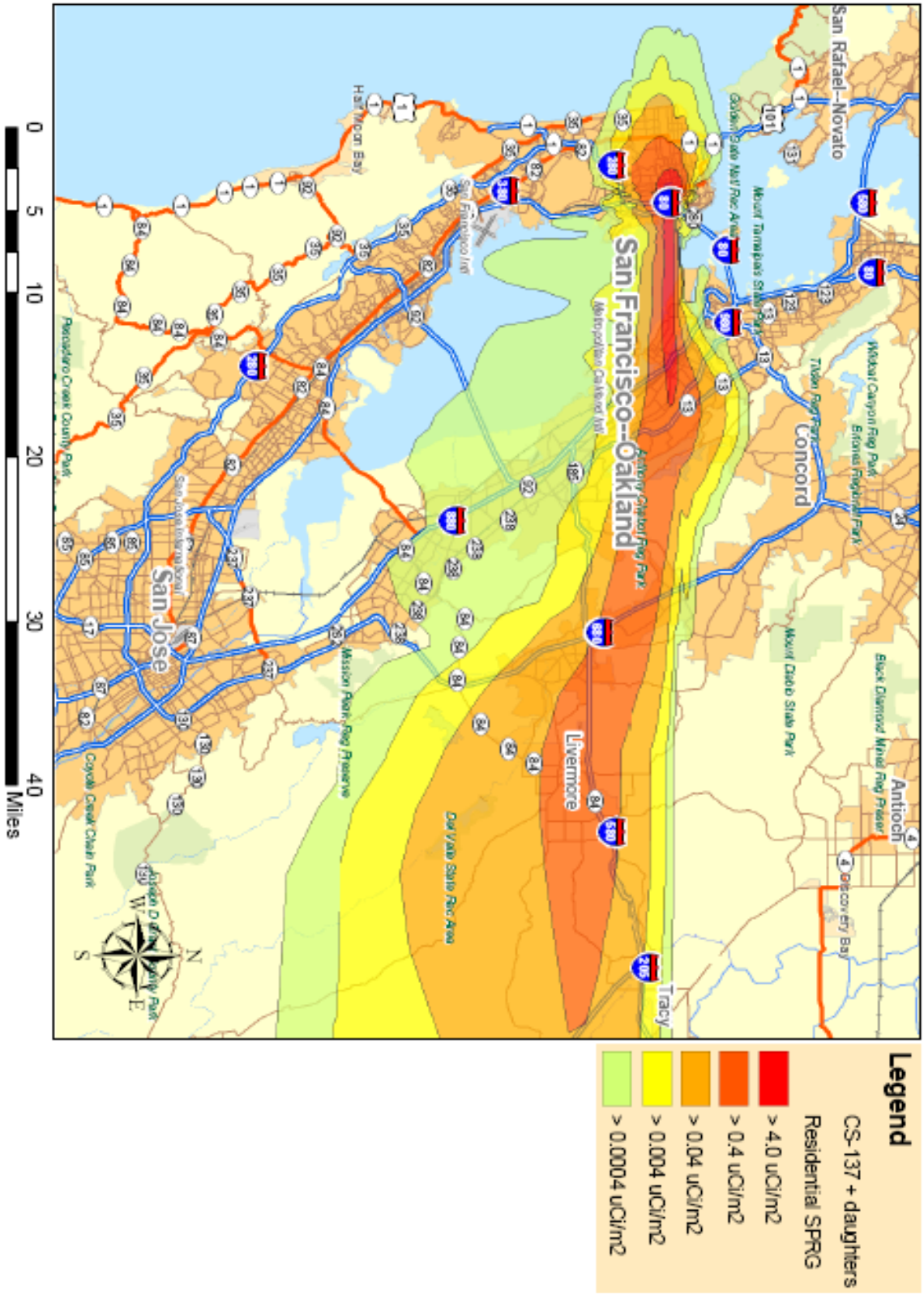

IND Relocation (1st Year)
2000 mREM/year
500mREM/year
Dublin
0 7.5 15 22.5 30 Km
0 3 6 9 12 15 Miles
IND Relocation

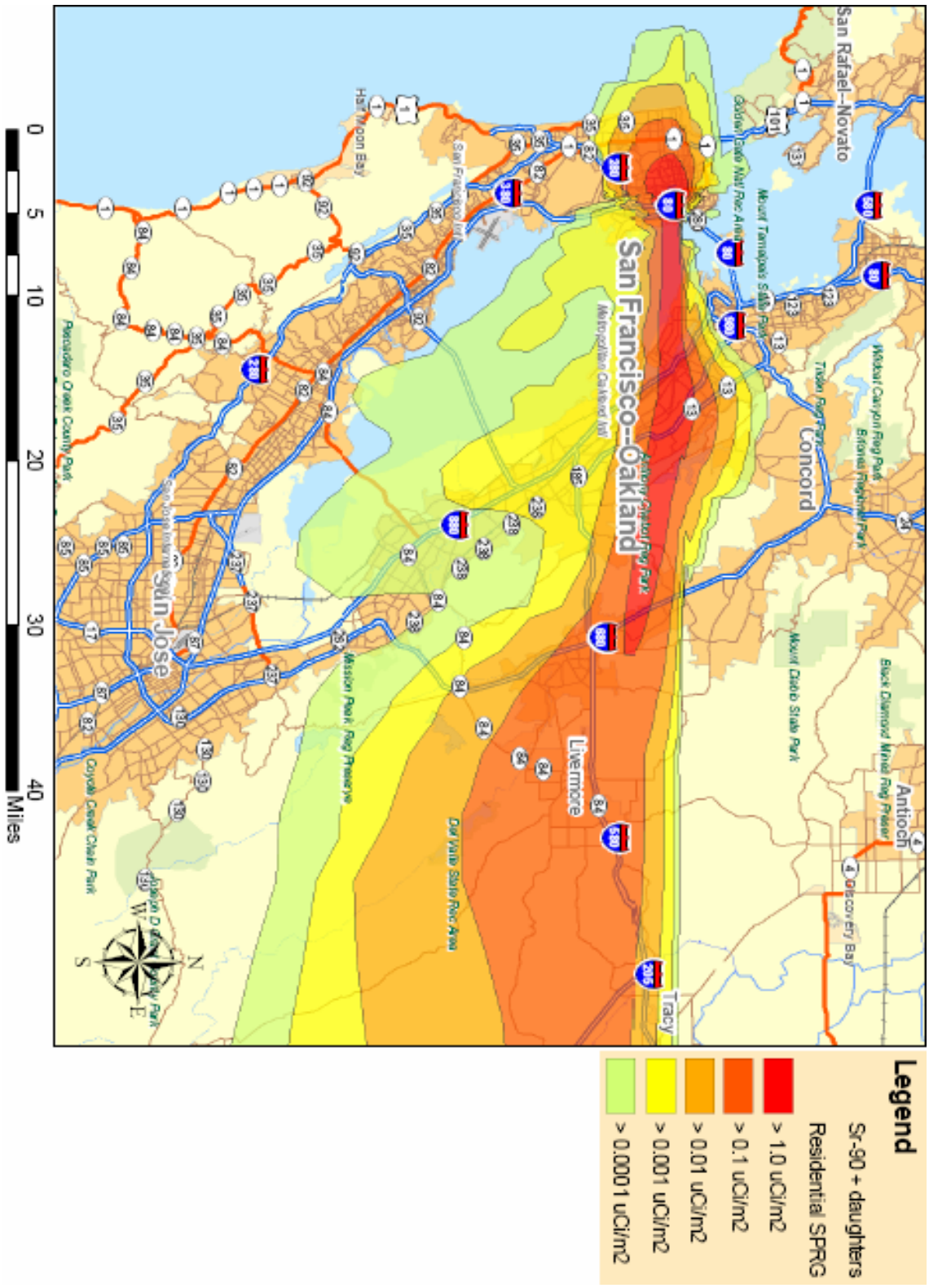

IND Relocation
0 10 20 30 40 50 60 Km
0 10 20 30 40 Miles
IND Relocation (1st Year)
2000 mREM/year
500mREM/year
Dublin
Tracy

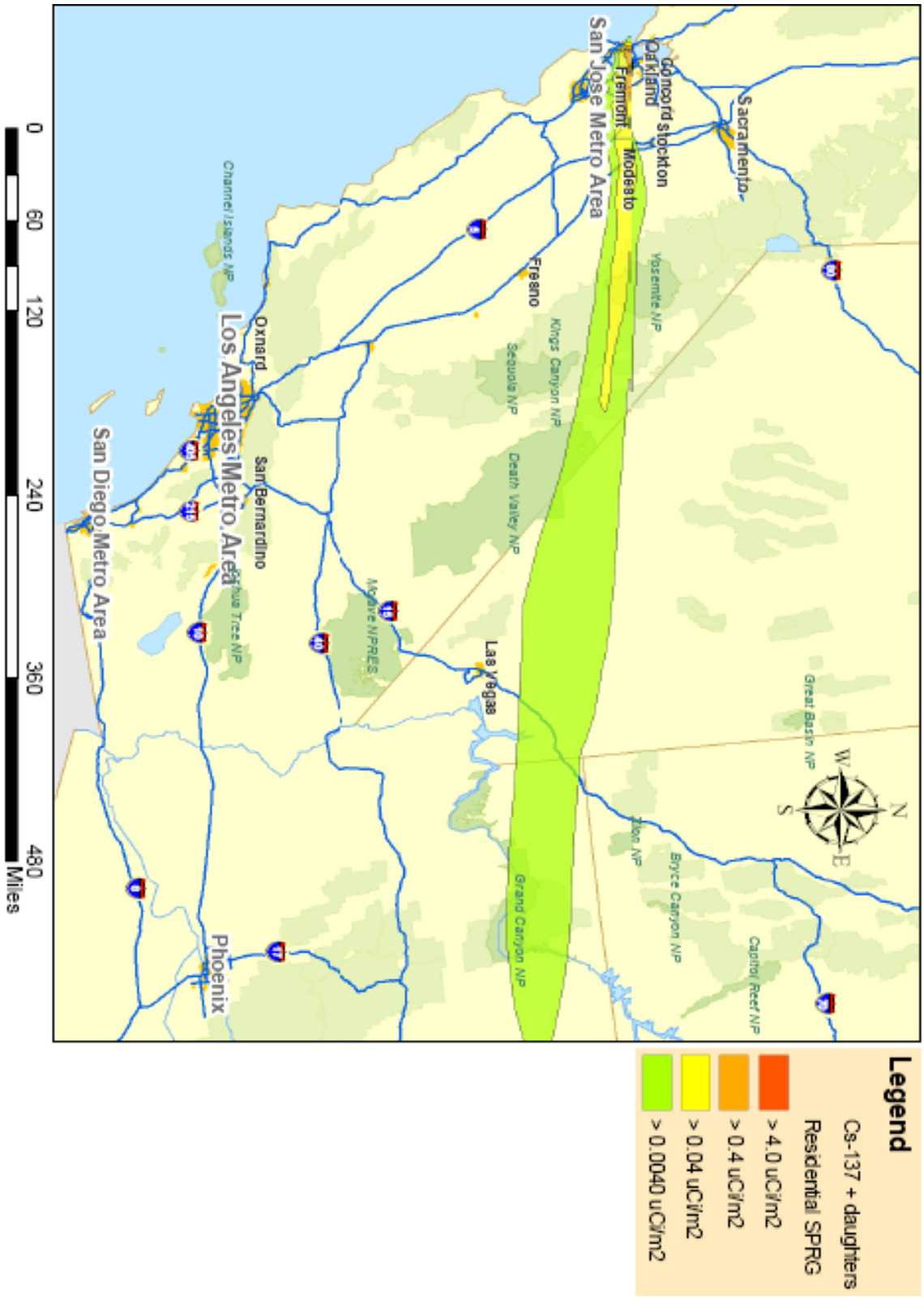

IND Relocation
0
40
80
120
160
200
240
Km
0
40
80
120
160
Miles
IND Relocation (1st Year)
2000 mREM/year
500mREM/year
Dublin
Tracy


IND Relocation (2nd Year)
2000 mREM/year
500 mRem/year
Dupont
Troy
0 8 16 24 32 40 48
Km
0 8 16 24 32
Miles
IND Relocation


IND Relocation
0 10 20 30 40 Miles
0 10 20 30 40 50 Km
IND Relocation (5th Year)
2000 mREM/year
500 mREM/year
Dublin
Tracy


San Rafael–Novato
San Francisco–Oakland
Concord
San Jose
Livermore
Antioch
Tracy
Legend
CS-137 + daughters
Residential SPRG
> 4.0 uCi/m2
> 0.4 uCi/m2
> 0.04 uCi/m2
> 0.004 uCi/m2
> 0.0004 uCi/m2
0
5
10
20
30
40
Miles


Legend
Sr-90 + daughters
Residential SPRG
> 1.0 uCi/m2
> 0.1 uCi/m2
> 0.01 uCi/m2
> 0.001 uCi/m2
> 0.0001 uCi/m2
San Rafael–Novato
Concord
San Francisco–Oakland
Livermore
Antioch
Tracy
San Jose
0
5
10
20
30
40
Miles


Legend
Cs-137 + daughters
Residential SPRG
> 4.0 uCi/m2
> 0.4 uCi/m2
> 0.04 uCi/m2
> 0.0040 uCi/m2
0
60
120
240
360
480
Miles
San Jose Metro Area
Oakland
Concord
Stockton
Fremont
Modesto
Sacramento
Fresno
Yosemite NP
Kings Canyon NP
Sequoia NP
Death Valley NP
Channel Islands NP
Oxnard
Los Angeles Metro Area
San Bernardino
Joshua Tree NP
Mojave NPRES
San Diego Metro Area
Las Vegas
Great Basin NP
Zion NP
Bryce Canyon NP
Grand Canyon NP
Capitol Reef NP
Phoenix
N
S
E
W

Discrete Areas

During the TTX, the participants were split into the same three technical workgroups for the IND scenario as with the RDD scenario. Each of these three technical workgroups was tasked to focus on how the cleanup of their discrete area would differ from cleanup under the RDD scenario. These three discrete areas were:

1. Haight-Ashbury (urban)

2. Dublin (suburban)

3. Tracy (rural)

Each of the three technical workgroups reviewed the following new handouts to facilitate determining what response approach they would recommend is used to address the discrete areas:

1. Baseline risk assessment chart showing the level of risk posed by the cesium and strontium contamination levels under different exposure scenarios representing land use, roadway types, settled dust or fixed contamination, and indoor or outdoors.

IND Table to use "IND scenario risks Haight Ashbury ver 2.xls"

Baseline Risk Assessment Table: IND Haight Ashbury **Urban**

Pre-remedial Concentrations *Outside*: Cesium-137+D 360 pCi/cm2 Strontium-90+D 1000 pCi/cm2

Pre-remedial Risk from *Outside* Concentrations

	Risk if Residential Urban local Rd [1]	Risk if Outdoor Worker Urban local Rd [2]	Risk if Indoor Worker Urban local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Strontium-90+D	9.90E-02	8.55E-02	5.32E-02	2.73E-02	7.25E-02	2.72E-02
Cesium-137+D	1.01E-02	7.52E-03	6.26E-03	5.29E-03	9.02E-03	5.27E-03

	Risk if Residential Urban Other Principal Arterial [7]	Risk if Outdoor Worker Urban Other Principal Arterial [8]	Risk if Indoor Worker Urban Other Principal Arterial [9]	Risk if Residential Urban Minor Arterial [10]	Risk if Outdoor Worker Urban Minor Arterial [11]	Risk if Indoor Worker Urban Minor Arterial [12]
Strontium-90+D	5.32E+00	1.14E+01	5.10E+00	2.72E+00	5.78E+00	2.58E+00
Cesium-137+D	2.09E-01	4.41E-01	1.99E-01	1.10E-01	2.25E-01	1.03E-01

	Risk if Residential Urban Collector [13]	Risk if Outdoor Worker Urban Collector [14]	Risk if Indoor Worker Urban Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]
Strontium-90+D	2.02E-01	3.10E-01	1.52E-01	1.43E-04	7.75E-05	3.45E-05
Cesium-137+D	1.40E-02	1.61E-02	1.01E-02	1.27E-03	6.88E-04	3.05E-04

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]
Strontium-90+D	2.45E-06	4.33E-03	9.26E-05	4.41E-05
Cesium-137+D	6.13E-05	6.03E-03	3.19E-03	1.42E-03

Pre-remedial Risk from *Inside* Concentrations

	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Comm/Ind [28]	Risk from Fixed 3-D if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if Inside Evacuated Bldg Comm/Ind [30]
Strontium-90+D	2.79E-01	3.03E-02	6.98E-02	7.56E-03	1.65E-03	3.47E-04	4.13E-04	8.68E-05
Cesium-137+D	3.81E-02	7.44E-03	9.52E-03	1.86E-03	9.51E-03	1.99E-03	2.38E-03	4.97E-04

IND Table to use footnotes "IND scenario risks Haight Ashbury ver 2.xls"

1 SPRG risk for Resident outside with California urban local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California urban local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California urban local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California urban other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California urban other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California urban other principal arterial (PEFm). 10 SPRG risk for Resident outside with California urban minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California urban minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California urban collector (PEFm). 13 SPRG risk for Resident outside with California urban collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California urban collector (PEFm). 15 SPRG risk for Indoor Worker outside with California urban collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEFw. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEF. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D.

	Soil Volume (g)	Ground Plane (cm^2)	
Am-241	2.76E-08	1.90E-08	
Cs-137+D	2.55E-06	5.09E-07	For these 4 scenarios we had to assume that the slope factors
Sr-90+D	1.96E-08	1.71E-08	were reasonably close to ratio concentrations of different units.

IND Table to use "IND scenario risks Dublin ver 2.xls"

Baseline Risk Assessment Table: IND Dublin **Suburban**

Pre-remedial Concentrations *Outside*: Cesium-137+D 12 pCi/cm2 Strontium-90+D 40 pCi/cm2

Pre-remedial Risk from *Outside* Concentrations

	Risk if Residential Urban local Rd [1]	Risk if Outdoor Worker Urban local Rd [2]	Risk if Indoor Worker Urban local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Strontium-90+D	3.96E-03	3.42E-03	2.13E-03	1.09E-03	2.90E-03	1.09E-03
Cesium-137+D	3.35E-04	2.51E-04	2.09E-04	1.76E-04	3.01E-04	1.76E-04

	Risk if Residential Urban Other Principal Arterial [7]	Risk if Outdoor Worker Urban Other Principal Arterial [8]	Risk if Indoor Worker Urban Other Principal Arterial [9]	Risk if Residential Urban Minor Arterial [10]	Risk if Outdoor Worker Urban Minor Arterial [11]	Risk if Indoor Worker Urban Minor Arterial [12]
Strontium-90+D	2.13E-01	4.57E-01	2.04E-01	1.09E-01	2.31E-01	1.03E-01
Cesium-137+D	6.98E-03	1.47E-02	6.63E-03	3.67E-03	7.50E-03	3.43E-03

	Risk if Residential Urban Collector [13]	Risk if Outdoor Worker Urban Collector [14]	Risk if Indoor Worker Urban Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]
Strontium-90+D	8.06E-03	1.24E-02	6.10E-03	5.71E-06	3.10E-06	1.38E-06
Cesium-137+D	4.65E-04	5.36E-04	3.35E-04	4.23E-05	2.29E-05	1.02E-05

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]
Strontium-90+D	9.80E-08	1.73E-04	3.70E-06	1.76E-06
Cesium-137+D	2.04E-06	2.01E-04	1.06E-04	4.74E-05

Pre-remedial Risk from *Inside* Concentrations

	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Comm/Ind [28]	Risk from Fixed 3-D if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if Inside Evacuated Bldg Comm/Ind [30]
Strontium-90+D	1.12E-02	1.21E-03	2.79E-03	3.03E-04	6.61E-05	1.39E-05	1.65E-05	3.47E-06
Cesium-137+D	1.27E-03	2.48E-04	3.17E-04	6.20E-05	3.17E-04	6.63E-05	7.93E-05	1.66E-05

IND Table to use footnotes "IND scenario risks Dublin ver 2.xls"

1 SPRG risk for Resident outside with California urban local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California urban local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California urban local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California urban other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California urban other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California urban other principal arterial (PEFm). 10 SPRG risk for Resident outside with California urban minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California urban minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California urban minor arterial (PEFm). 13 SPRG risk for Resident outside with California urban collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California urban collector (PEFm). 15 SPRG risk for Indoor Worker outside with California urban collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEFw. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEF. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG Fixed 3-D. 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D.

	Soil Volume (q) Ground Plane (cm^2)		
Am-241	2.76E-08	1.90E-08	
Cs-137+D	2.55E-06	5.09E-07	For these 4 scenarios we had to assume that the slope factors
Sr-90+D	1.96E-08	1.71E-08	were reasonably close to ratio concentrations of different units.

IND Table to use "IND scenario risks Tracy ver 2.xls"

Baseline Risk Assessment Table: IND Tracy **Rural**

Pre-remedial Concentrations *Outside*: Strontium-90+D 15 pCi/cm2 Cesium-137+D 2 pCi/cm2

Pre-remedial Risk from *Outside* Concentrations

	Risk if Residential Rural local Rd [1]	Risk if Outdoor Worker Rural local Rd [2]	Risk if Indoor Worker Rural local Rd [3]	Risk if Residential Default No Cars PEFw [4]	Risk if Outdoor Worker Default No Cars PEFw [5]	Risk if Indoor Worker Default No Cars PEFw [6]
Strontium-90+D	1.07E-03	3.95E-04	4.01E-04	4.10E-04	1.09E-03	4.09E-04
Cesium-137+D	5.00E-05	2.91E-05	2.92E-05	2.94E-05	5.01E-05	2.93E-05

	Risk if Residential Rural Other Principal Arterial [7]	Risk if Outdoor Worker Rural Other Principal Arterial [9]	Risk if Indoor Worker Rural Other Principal Arterial [9]	Risk if Residential Rural Minor Arterial [10]	Risk if Outdoor Worker Rural Minor Arterial [11]	Risk if Indoor Worker Rural Minor Arterial [12]
Strontium-90+D	4.64E-02	9.93E-02	4.42E-02	3.00E-03	4.59E-03	2.27E-03
Cesium-137+D	6.92E-04	1.43E-03	6.49E-04	7.72E-05	8.85E-05	5.56E-05

	Risk if Residential Rural Major Collector [13]	Risk if Outdoor Worker Rural Major Collector [14]	Risk if Indoor Worker Rural Major Collector [15]	Risk if Residential Fixed Contamination [16]	Risk if Outdoor Worker Fixed Contamination [17]	Risk if Indoor Worker Fixed Contamination [18]	Fixed 3-D Risk Inside Unevacuated Bldg Agricultural [35]	Fixed 3-D Risk Inside Evacuated Bldg Agricultural [36]
Strontium-90+D	1.47E-03	1.27E-03	7.89E-04	2.14E-06	1.16E-06	5.17E-07	3.00E-05	7.50E-06
Cesium-137+D	5.57E-05	4.16E-05	3.47E-05	7.04E-06	3.82E-06	1.69E-06	6.37E-05	1.59E-05

	Risk if local park/playground [19]	Risk if Resident Yard [20]	Risk if Outdoor Worker Yard [21]	Risk if Indoor Worker Yard [22]	Risk if Agriculture Land (Subsistence Farmer) [31]	Risk if Agriculture Land (Typical Farmer) [32]	Dust Risk Inside Unevacuated Bldg Agricultural [33]	Dust Risk Inside Evacuated Bldg Agricultural [34]
Strontium-90+D	3.68E-08	6.49E-05	1.39E-06	6.61E-07	1.08E-02	1.14E-03	4.67E-03	6.22E-06
Cesium-137+D	3.41E-07	3.35E-05	1.77E-05	7.91E-06	1.67E-03	1.61E-03	2.40E-04	2.40E-04

Pre-remedial Risk from *Inside* Concentrations

	Risk from Dust if Inside Unevacuated Bldg Residential [23]	Risk from Dust if Inside Unevacuated Bldg Comm/Ind [24]	Risk from Dust if Inside Evacuated Bldg Residential [25]	Risk from Dust if Inside Evacuated Bldg Comm/Ind [26]	Risk from Fixed 3-D if Inside Unevacuated Bldg Residential [27]	Risk from Fixed 3-D if Inside Unevacuated Bldg Comm/Ind [28]	Risk from Fixed 3-D if Inside Evacuated Bldg Residential [29]	Risk from Fixed 3-D if Inside Evacuated Bldg Comm/Ind [30]
Strontium-90+D	4.19E-03	4.54E-04	1.05E-03	1.13E-04	2.48E-05	5.21E-06	6.20E-06	1.30E-06
Cesium-137+D	2.12E-04	4.13E-05	5.29E-05	1.03E-05	5.28E-05	1.10E-05	1.32E-05	2.76E-06

IND Table to use footnotes "IND scenario risks Tracy ver 2.xls"

1 SPRG risk for Resident outside with California Rural local roadway (PEFm). 2 SPRG risk for Outdoor Worker outside with California Rural local roadway (PEFm). 3 SPRG risk for Indoor Worker outside with California Rural local roadway (PEFm). 4 SPRG risk for Resident outside with Default (PEFw). 5 SPRG risk for Outdoor Worker outside with Default (PEFw). 6 SPRG risk for Indoor Worker outside with Default (PEFw). 7 SPRG risk for Resident outside with California Rural other principal arterial (PEFm). 8 SPRG risk for Outdoor Worker outside with California Rural other principal arterial (PEFm). 9 SPRG risk for Indoor Worker outside with California Rural other principal arterial (PEFm). 10 SPRG risk for Resident outside with California Rural minor arterial (PEFm). 11 SPRG risk for Outdoor Worker outside with California Rural minor arterial (PEFm). 12 SPRG risk for Indoor Worker outside with California Rural minor arterial (PEFm). 13 SPRG risk for Resident outside with California Rural major collector (PEFm). 14 SPRG risk for Outdoor Worker outside with California Rural major collector (PEFm). 15 SPRG risk for Indoor Worker outside with California Rural major collector (PEFm). 16 SPRG risk for Resident outside with fixed 3-D contamination. 17 SPRG risk for Outdoor Worker outside with fixed 3-D contamination. 18 SPRG risk for Indoor Worker outside with fixed 3-D contamination. 19 RAIS default recreator for SF and 500 acres. 20 PRG risk outside for resident from PRG with SF and largest area for PEFw. 21 PRG risk outside for outdoor worker from PRG with SF and largest area for PEF. 22 PRG risk outside for indoor worker from PRG with SF and largest area for PEF. 23 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 24 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG settled dust. 25 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 26 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG settled dust. 27 BPRG risk for Indoor Resident that assumes 2 times the outdoor concentration get inside from BPRG fixed 3-D.

28 BPRG risk for Indoor Worker that assumes 2 times the outdoor concentration get inside from BPRG fixed 3-D 29 BPRG risk for Indoor Resident that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 30 BPRG risk for Indoor Worker that assumes 1/2 times the outdoor concentration get inside from BPRG Fixed 3-D. 31 PRG risk Agriculture Default. 32 PRG risk Agricultural Typical Farmer using contaminated plant fractions from Superfund SDEF. 33 BPRG dust risk for Unevacuated Agricultural. 34 BPRG dust risk for Evacuated Agricultural. 35 BPRG Fixed 3-D risk for Unevacuated Agricultural. 36 BPRG Fixed 3-D risk for Evacuated Agricultural.

	Soil Volume (q)	Ground Plane (cm^2)	
Am-241	2.76E-08	1.90E-08	For these 6 scenarios we had to assume that the slope factors were reasonably close to ratio concentrations of different units.
Cs-137+D	2.55E-06	5.09E-07	
Sr-90+D	1.96E-08	1.71E-08	

Results of Pilot Late-Phase Response TTX

The late-phase RDD/IND TTX was piloted on Monday February 26, 2007 in San Francisco for several reasons. These include that the instructors would be in town for EPA's annual National Superfund Radiation meeting that would be held from Tuesday to Friday that week, and to foster dialogue with the participants at the larger national meeting about this pilot version of the TTX and subsequent revised versions. Having the national meeting in the same city as the U.S. EPA Region 9 office facilitated having participation of Region 9 staff with a wider range of disciplines than those attending the national meeting.

Participation

It was decided to limit the participation in the TTX to EPA staff since this was the first attempt at this type of focused late-phase TTX. EPA staff involved in developing the TTX wanted to ensure through validation that the TTX was sufficiently developed before having non-EPA participants.

The EPA participants in the TTX included:

1. 5 Remedial Project Managers (RPMs)

2. 7 On-Scene Coordinators (OSCs) and removal program managers

3. 6 Radiation technical support personnel

4. 4 Homeland security support personnel

5. 5 Community Involvement Coordinators (CICs)

Lessons Learned

Most of the lessons learned from the participants in the TTX were ideas on how to run the TTX better. The primary lessons learned may be summarized as follows:

1. The TTX was a good idea. It made participants think about the long-term recovery and response issues that would arise in an actual event.

   -- Improve the TTX through an iterative process and then conduct the TTX in the other 9 EPA Regions.

2. Focus the TTX more on the RDD, and less on the IND.

3. Be more specific about the role of EPA and other agencies, particularly in background TTX materials. Do a better job of reconciling PAGs, emergency response and long-

term cleanup.

4. Provide more linkage of the late-phase TTX to the early and intermediate response actions that were taken. For example:

   -- What cleanup actions have already been taken prior to the late-phase?

   -- What other decisions have been made or processes established (e.g., disposal location, decontamination procedures). Include statements concerning what was implemented in the early and intermediate phases.

5. Include EPA regional staff as participants from divisions other than Superfund (e.g., air, water divisions).

6. Tie the three discrete areas (urban, suburban, rural) together better with some common elements (e.g., monitoring)

7. Provide more specific instructions to the participants about the expected outcomes.

   -- What do you want us to accomplish?

8. Provide interim debrief opportunities to ensure that the groups are focused on relevant exercise problem areas and allow across group exchanges to serve as reference points.

Appendix A: Background Reading Material

One week prior to the TTX, the following email was sent out to expected participants. The email suggested several short sources of background information that the participants might wish to read before attending the TTX.

Stuart Walker/DC/USEPA/US 02/20/2007 05:51 PM	To	Kathy Setian/R9/USEPA/US@EPA, Andrew Bain/R9/USEPA/US@EPA, John Beach/R9/USEPA/US@EPA, Pankaj Arora/R9/USEPA/US@EPA, DENISE BOONE/R5/USEPA/US@EPA, Will Duncan/R9/USEPA/US@EPA, Daniel Suter/R9/USEPA/US@EPA, HarryL Allen/R9/USEPA/US@EPA, Peter Guria/R9/USEPA/US@EPA, Daniel Meer/R9/USEPA/US@EPA, Kathryn Lawrence/R9/USEPA/US@EPA, Mike Bandrowski/R9/USEPA/US@EPA, Ed Snyder/R9/USEPA/US@EPA, Shelly Rosenblum/R9/USEPA/US@EPA, Robert Terry/R9/USEPA/US@EPA, Harold Ball/R9/USEPA/US@EPA, Lauren Volpini/R9/USEPA/US@EPA, Barbara Maco/R9/USEPA/US@EPA, John Kennedy/R9/USEPA/US@EPA, PuiMan Wong/R9/USEPA/US@EPA, Jose Garcia/R9/USEPA/US@EPA, Luis Garcia-Bakarich/R9/USEPA/US@EPA, Vicki Rosen/R9/USEPA/US@EPA Douglas Sarno <djsarno@theperspectivesgroup.com>, EUGENE JABLONOWSKI/R5/USEPA/US@EPA, James
	cc	Mitchell/R5/USEPA/US@EPA, Scott Hudson/CI/USEPA/US@EPA, John Cardarelli/CI/USEPA/US@EPA, RobinM Anderson/DC/USEPA/US@EPA, Charles Sands/DC/USEPA/US@EPA, Sara DeCair/DC/USEPA/US@EPA
	bcc	
	Subject	Potential background reading material for Monday's Tabletop Exercise

Dear WMD Tabletop Participant:

We look forward to your participation in next Monday's Tabletop Exercise (TTX). Because we will have participant from a variety of backgrounds, it is important that we have a base of common knowledge. Below are hotlinks to a variety of material that you may find useful as background. They have been organized into information that you must understand and additional information that may be of interest.

Information You Need to Understand to Participate

Fact sheet on terrorist attack using a Radiological Dispersal Device (RDD) more commonly known as a "dirty bomb"
http://www.nae.edu/NAE/pubundcom.nsf/weblinks/CGOZ-646NVG/$file/radiological%20attack%2006.pdf

Fact sheet on terrorist attack using an Improvised Nucear Device (IND)
http://www.nae.edu/NAE/pubundcom.nsf/weblinks/CGOZ-6DZLNU/$file/nuclear%20attack%2006.pdf

Fact sheet on EPA Superfund process for selecting site cleanup approach
http://www.epa.gov/superfund/resources/remedy/pdf/93-55027fs.pdf

Monday's TTX will focus on the cleanup of 3 radionuclides (Americium-241, Cesium-137, and Strontium-90). Here are EPA fact sheets for the general public that provide some background for each of these radionuclides.
http://www.epa.gov/superfund/resources/radiation/pdf/amercium.pdf
http://www.epa.gov/superfund/resources/radiation/pdf/cesium.pdf
http://www.epa.gov/superfund/resources/radiation/pdf/strontium.pdf

Additional Information that may be Useful to You

At most Superfund remedial actions, a combination of existing material and site-specific fact sheets may also be used for community Involvement efforts. This approach could also be used in the late-phase related to an RDD or IND attack.

video on EPA Superfund risk assessment approach for radioactively contaminated sites
http://www.epa.gov/superfund/resources/radiation/radvideo.htm

booklet on common radionuclides found at superfund site
http://www.epa.gov/superfund/resources/radiation/radcomm.htm

general Superfund community involvement webpages
http://www.epa.gov/superfund/action/community/index.htm
http://www.epa.gov/superfund/action/guidance/remedy/cominvolve.htm
http://www.epa.gov/superfund/action/community/involvement.htm

webpage and flyers for EPA response after World Trade Center incident
http://www.epa.gov/wtc/
http://www.epa.gov/wtc/flyers/onepagead.pdf
http://www.epa.gov/wtc/flyers/newspaper_ad.pdf

webpage, handouts, and public service announcements for EPA response after hurricanes Katrina and Rita
http://www.epa.gov/katrina/index.html
http://www.epa.gov/katrina/outreach/handouts.html
http://www.epa.gov/katrina/outreach/returning-general.pdf
http://www.epa.gov/katrina/outreach/psa.html

Appendix B: Presentation for TTX Participants

At the beginning of the TTX, the developers of the TTX provided the following presentation to the participants. This was intended to provide an overview of information regarding:

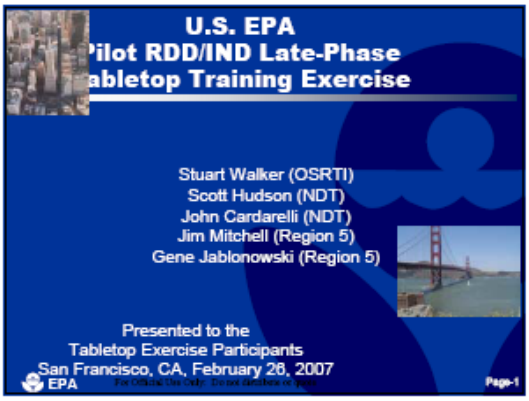
1. the DHS PAGs process and the potential use during the late-phase of a modified CERCLA cleanup approach

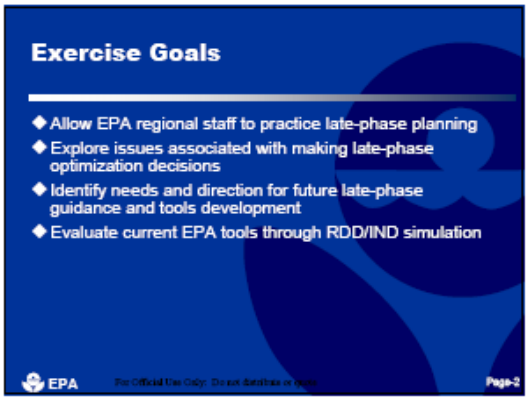
2. potential decontamination technologies

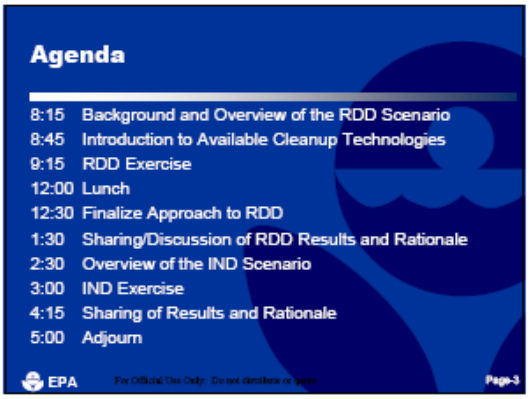
3. the RDD scenario

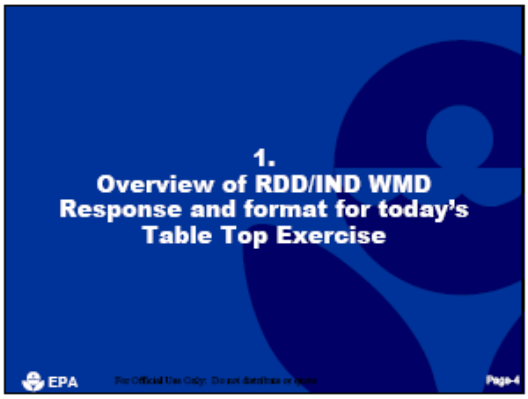
4. the IND scenario

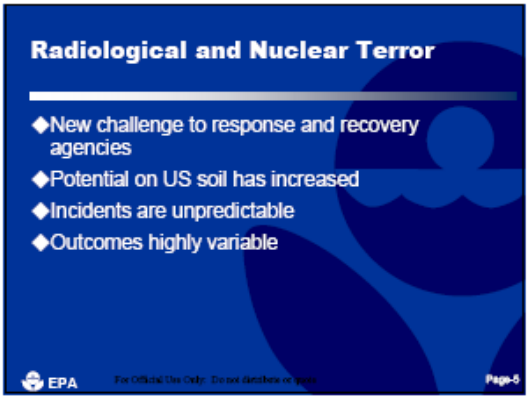
Attached is the powerpoint presentation that was used to brief the TTX participants. The handouts for the TTX for each of the three discrete areas (e.g., Haight-Ashbury, Dublin, Tracy) are provided in the earlier descriptions for the RDD and IND scenarios.

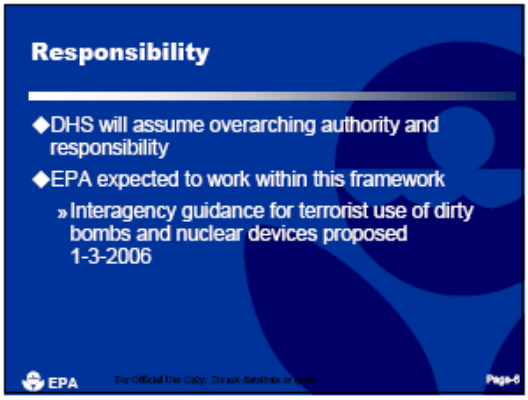

U.S. EPA
ilot RDD/IND Late-Phase
abletop Training Exercise
Stuart Walker (OSRTI)
Scott Hudson (NDT)
John Cardarelli (NDT)
Jim Mitchell (Region 5)
Gene Jablonowski (Region 5)
Presented to the
Tabletop Exercise Participants
San Francisco, CA, February 26, 2007
EPA
Page-1


Exercise Goals
◆Allow EPA regional staff to practice late-phase planning
◆Explore issues associated with making late-phase optimization decisions
◆Identify needs and direction for future late-phase guidance and tools development
◆Evaluate current EPA tools through RDD/IND simulation
EPA
Page-2


Agenda
8:15 Background and Overview of the RDD Scenario
8:45 Introduction to Available Cleanup Technologies
9:15 RDD Exercise
12:00 Lunch
12:30 Finalize Approach to RDD
1:30 Sharing/Discussion of RDD Results and Rationale
2:30 Overview of the IND Scenario
3:00 IND Exercise
4:15 Sharing of Results and Rationale
5:00 Adjourn
EPA
Page-3


1.
Overview of RDD/IND WMD
Response and format for today's
Table Top Exercise
EPA
Page-4


Radiological and Nuclear Terror
◆New challenge to response and recovery agencies
◆Potential on US soil has increased
◆Incidents are unpredictable
◆Outcomes highly variable
EPA
Page-5


Responsibility
◆DHS will assume overarching authority and responsibility
◆EPA expected to work within this framework
» Interagency guidance for terrorist use of dirty bombs and nuclear devices proposed 1-3-2006
EPA
Page-6

Protective Action Guides (PAGs)

- The projected dose from an unplanned release of radioactive material at which a protective action is warranted
- By necessity are forward-looking
- Developed for all incidents of radiological release to the environment
- Developed using NPP accidents as likely "worst case"

EPA

Phases of a Radiation Response

- Early (hours to days)
  - » plume is active, little if any field data
  - » Protect public health, prompt decision-making, little data
- Intermediate (days to months)
  - » source under control, field data coming in
  - » Better decisions based on more data, temporary entry and personal property issues
  - » Begin planning long-term actions
- Late (months to years)
  - » long term site clean up and restoration
  - » Site-specific, multi-attribute recovery decision-making

EPA

PHASE	PROTECTIVE ACTION	DHS RDD/IND PROTECTIVE ACTION GUIDE
Early	Limit Emergency Worker Exposure	Normally 5 rems, higher values under emergency circumstances as needed
	Sheltering of Public	1 to 5 rem projected dose, normally initiated at 1 rem
	Evacuation of Public	1 to 5 rem projected dose, normally initiated at 1 rem
	Administration of Prophylactic Drugs	For KI, FDA Guidance dose values. For other drugs, consider on an ad hoc basis
Intermediate	Limit Worker Exposure	5 rems in compliance with OSHA regulations
	Relocation of General Public	2 rems, projected dose 1st Year
		Any subsequent year: 500 mrem projected dose
	Food Interdiction	500 mrem projected dose
	Drinking Water Interdiction	500 mrem dose
Late	Final cleanup actions	Site specific level based on Optimization (focus of this Tabletop)

EPA

RDD/IND Clean Up Coming to EPA

- National Response Plan (Nuclear/Radiological Annex) assigns to EPA the role of Coordinating Agency for clean up and recovery following acts of nuclear and radiological terrorism
- Duties described in NRP ESF#10 also apply to radiological materials
- NRP is being revised, notion of coordinating agency may be eliminated

EPA

DHS Guidance is NOT to be Used for CERCLA Response

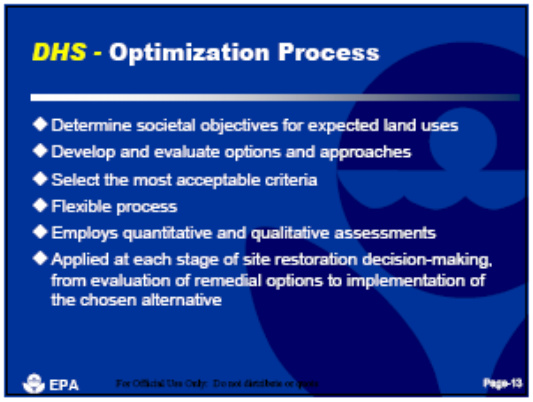
- Do not use DHS optimization approach for selecting remedies
  - » Continue to use NCP 9 criteria for remedial (e.g., 10^{-4} to 10^{-6}, ARARs)
  - » Removal approach unchanged
- Do not use DHS early or intermediate PAGs as TBC
  - » CERCLA cleanup levels ***not*** based on guidance outside the risk range and/or expressed as a dose (# mrem/yr)
- Do not use DHS recovery process

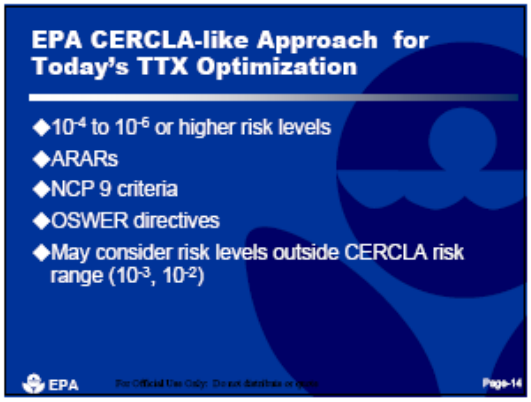
EPA

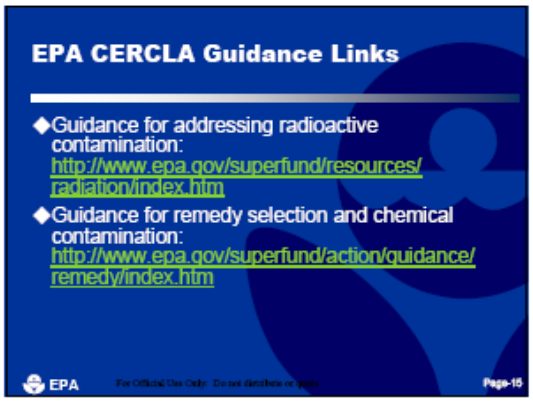
DHS - Late Phase PAG

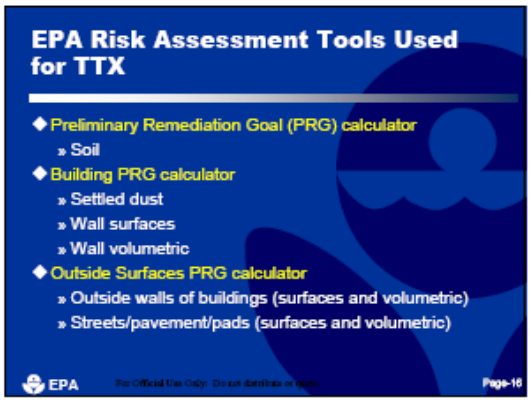
- Due to the extreme range of potential impacts, Subgroup determined that a numerical approach was not useful
- Subgroup determined that site-specific remediation and recovery strategies should be developed using principals of optimization

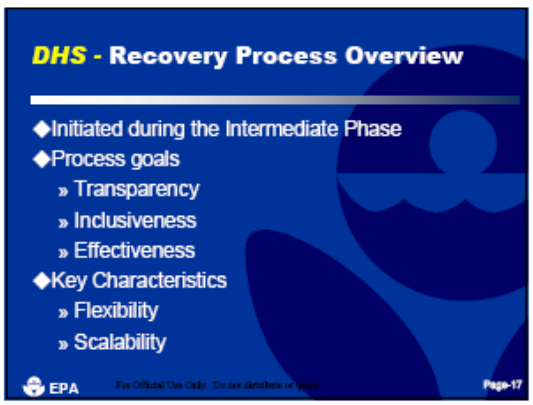
EPA

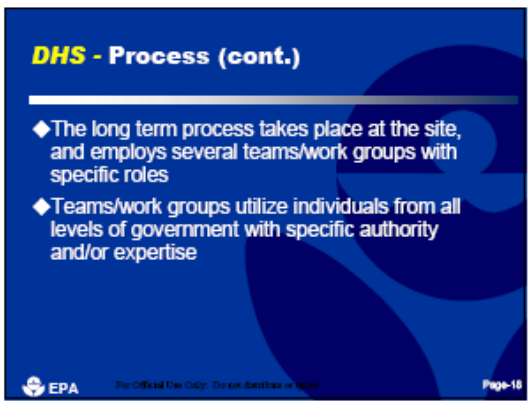

DHS - Optimization Process
◆Determine societal objectives for expected land uses
◆Develop and evaluate options and approaches
◆Select the most acceptable criteria
◆Flexible process
◆Employs quantitative and qualitative assessments
◆Applied at each stage of site restoration decision-making, from evaluation of remedial options to implementation of the chosen alternative
EPA
Page-13


EPA CERCLA-like Approach for Today's TTX Optimization
◆10^{-4} to 10^{-6} or higher risk levels
◆ARARs
◆NCP 9 criteria
◆OSWER directives
◆May consider risk levels outside CERCLA risk range (10^{-3}, 10^{-2})
EPA
Page-14


EPA CERCLA Guidance Links
◆Guidance for addressing radioactive contamination: http://www.epa.gov/superfund/resources/radiation/index.htm
◆Guidance for remedy selection and chemical contamination: http://www.epa.gov/superfund/action/guidance/remedy/index.htm
EPA
Page-15


EPA Risk Assessment Tools Used for TTX
◆Preliminary Remediation Goal (PRG) calculator
» Soil
◆Building PRG calculator
» Settled dust
» Wall surfaces
» Wall volumetric
◆Outside Surfaces PRG calculator
» Outside walls of buildings (surfaces and volumetric)
» Streets/pavement/pads (surfaces and volumetric)
EPA
Page-16


DHS - Recovery Process Overview
◆Initiated during the Intermediate Phase
◆Process goals
» Transparency
» Inclusiveness
» Effectiveness
◆Key Characteristics
» Flexibility
» Scalability
EPA
Page-17


DHS - Process (cont.)
◆The long term process takes place at the site, and employs several teams/work groups with specific roles
◆Teams/work groups utilize individuals from all levels of government with specific authority and/or expertise
EPA
Page-18

DHS Response Teams and Groups

- Decision Team (DT)
- Recovery Management Team (RMT)
- Stakeholder Work Group (SWG)
- Technical Work Group (TWG)
  - TTX exercise will focus on this role

EPA

DHS - Recovery Process

- Through iterative process, TWG develops and forwards a sound, reasonable, and balanced remediation recommendation to the RMT for approval
- RMT transmits the approved recommendation(s) to the DT for final action
- The DT publishes a summary of the process, the options analyzed, and the final recommendation for public comment
- Public comments responded to, considered, and incorporated as appropriate (reconvening of the RMT, SWG and TWG may be necessary)
- Recovery operations implemented and evaluated for effectiveness

EPA

DHS - Team Coordination

- TWG works with the SWG so that local concerns can inform the work of the TWG
- TWG informs stakeholders of remediation options, feasibility, strengths and weaknesses
- Regular meetings of the RMT, SWG and TWG to
  - facilitate consultation on site-specific goals, needs, and expectations
  - share status of work products
  - transmit findings
  - discuss remediation options pros and cons
  - share information on trends and developments

EPA

2. Primer on Cleanup Approaches Considered in Today's Tabletop

EPA

Decontamination Technologies Primary Resource

- Chemical and Physical Technologies
  - Description
  - Target contaminates
  - Applicable media
  - Waste Streams
  - Operating Characteristics
  - Performance
  - Operating Costs
  - Commercial Availability
  - Emerging Technologies

EPA

Materials in an Urban Environment

Material	%
Brick	30
Concrete	30
Asphalt	30
Glass/Metal	8
Wood / Treated	2

Source: LANL Report: LA-CP-03-0575

Canepa et al., 2003. Decontamination Efficiencies and Factors for Radioactive Contamination of Urban Environments

EPA

Decontamination Technologies – short list

- **Common**
  - Wash / pressure wash
  - Steam cleaning
  - Vacuum
- **Physical**
  - Strippable Coatings
  - Concrete Shaver
  - Media Blast Cleaning
- **Chemical**
  - TechXtract
- **Other**
  - Deep plowing / excavating
  - Road resurfacing / paving

EPA

High Pressure Water

Simple flushing with water is the basic approach to surface decontamination. Increased pressures and flow-rates enhance the mechanical effects of the water stream.

High Pressure Water

- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability

EPA

High Pressure Water

- **Advantages**
  - useful for difficult to access surfaces,
  - decon complex geometric structures,
  - widely available technology,
  - numerous equipment setups for a variety of applications.
- **Disadvantages**
  - wastewater containment and treatment considerations,
  - not usable on wood, or fibrous materials.

EPA

High Pressure Water Uses in an Urban Environment

- Readily available technology.
- Waste water containment and treatment issues.
- Requires additional attachments to address irregular surfaces, obstacles, and tight places.
- Can improve effectiveness by adding chelators / surfactants
- The quality of performance data available to address this factor was judged to be ADEQUATE.

EPA

Chelators

- Oxalic acid
- Citric acid
- Gluconic acid
- Ethylenediaminetetraacetic acid (EDTA)
- Hydroxyethelyenediaminetriacetic acid (HEDTA)
- Ethylenediaminediscuccinic acid (OEDPA)
- Diethylenetriaminepentaacetic acid (DTPA)

Selective chelating solutions
MOXCOL®-100 – Fe oxides
MOXCOL®-550 – $CaCO_3$ and $Mg(OH)_2$
MOXCOL®-670 – Al, Al Cl oxides, $Zn_3(PO_4)_2$, $CaCO_3$, $Mg(OH)_2$ and $CaSO_4$
MOXCOL®-771 – Sr, Ba, and Ra sulfates

EPA

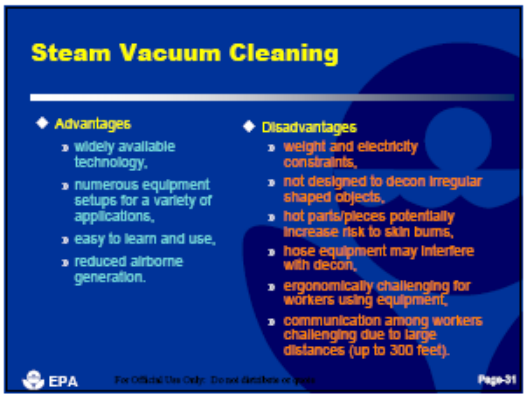
Steam Vacuum Cleaning

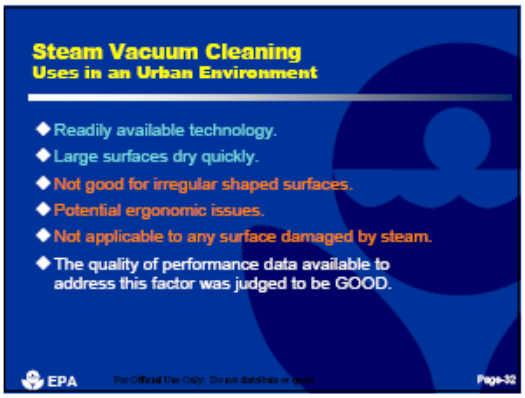
Similar to high pressure cleaning except superheated water is applied under pressure.

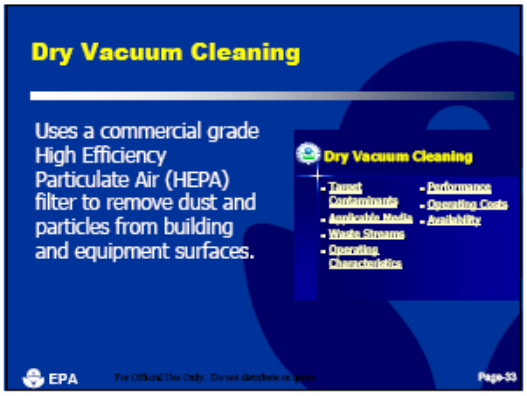
Steam Vacuum Cleaning

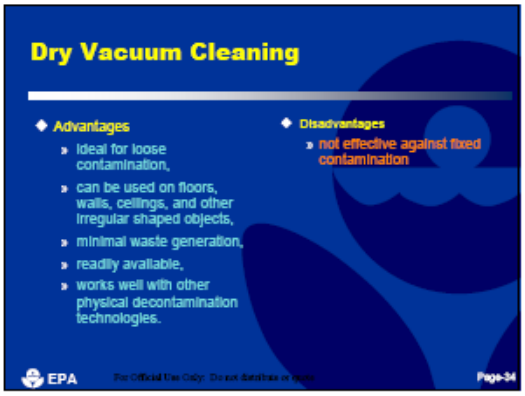
- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability

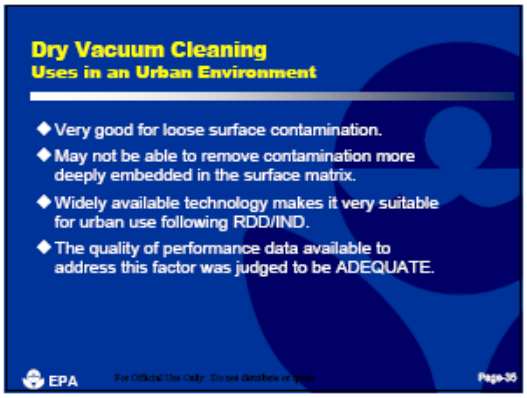
EPA

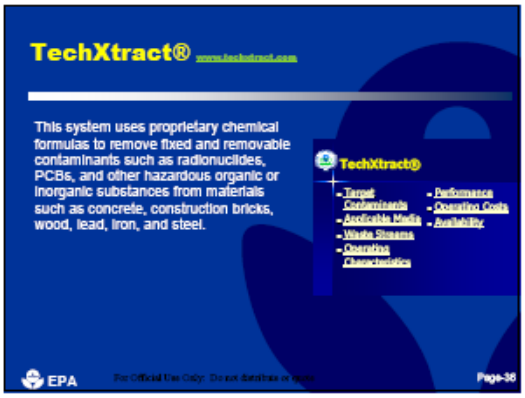

Steam Vacuum Cleaning
Advantages
» widely available technology,
» numerous equipment setups for a variety of applications,
» easy to learn and use,
» reduced airborne generation.
Disadvantages
» weight and electricity constraints,
» not designed to decon irregular shaped objects,
» hot parts/pieces potentially increase risk to skin burns,
» hose equipment may interfere with decon,
» ergonomically challenging for workers using equipment,
» communication among workers challenging due to large distances (up to 300 feet).
EPA


Steam Vacuum Cleaning
Uses in an Urban Environment
Readily available technology.
Large surfaces dry quickly.
Not good for irregular shaped surfaces.
Potential ergonomic issues.
Not applicable to any surface damaged by steam.
The quality of performance data available to address this factor was judged to be GOOD.
EPA


Dry Vacuum Cleaning
Uses a commercial grade High Efficiency Particulate Air (HEPA) filter to remove dust and particles from building and equipment surfaces.
Dry Vacuum Cleaning
- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability
EPA


Dry Vacuum Cleaning
Advantages
» ideal for loose contamination,
» can be used on floors, walls, ceilings, and other irregular shaped objects,
» minimal waste generation,
» readily available,
» works well with other physical decontamination technologies.
Disadvantages
» not effective against fixed contamination
EPA


Dry Vacuum Cleaning
Uses in an Urban Environment
Very good for loose surface contamination.
May not be able to remove contamination more deeply embedded in the surface matrix.
Widely available technology makes it very suitable for urban use following RDD/IND.
The quality of performance data available to address this factor was judged to be ADEQUATE.
EPA


TechXtract®
This system uses proprietary chemical formulas to remove fixed and removable contaminants such as radionuclides, PCBs, and other hazardous organic or inorganic substances from materials such as concrete, construction bricks, wood, lead, iron, and steel.
TechXtract®
- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability
EPA

TechXtract®

- Advantages
  - Highly flexible,
  - Tailored to specific contaminant,
  - Best for batch operations with small objects or small areas,
  - Can be used to decon equipment for re-use,
  - produces low volumes of waste,
  - little risk of aerosol generation.
- Disadvantages
  - Requires optimization for contaminant and substrate,
  - Dependent on a single vendor,
  - Health and Safety issues (handling industry strength cleaners),
  - waste management issues (must neutralize),
  - concentrates radionuclides leading to increase exposure potentials.

EPA Page-37

TechXtract® Uses in an Urban Environment

- The acceptable level for any residual contaminant is very low (e.g., free release at 5,000 dpm/100 cm^2 or lower), but these levels may not be acceptable following an RDD.
- Simple surface cleaning is ineffective.
- Bulk disposal is undesirable, either because the volume and resulting disposal and replacement costs are too high, or due to resource recycle or waste minimization objectives.
- Significant safety concerns are raised (e.g. flammability, corrosivity, creation of airborne contaminant particles, fugitive emissions or generation of toxic fumes and/or explosive gases)
- Best used in batch operations or small areas.
- The quality of performance data available to address this factor was judged to be GOOD.

EPA Page-38

Physical Decon Techniques

- Surface Cleaning*
  - brushing
  - wiping
  - flushing
  - vacuuming
  - strippable coatings

* surface remains intact

- Surface Removal*
  - grinding
  - blasting
  - scabbling
  - shaving
  - spalling
  - peening
  - scaling

* layer is removed from surface

EPA Page-39

Physical Decontamination

- Advantages
  - works on most surfaces,
  - may be only option on porous materials,
  - achieves higher DF than chemical décon,
  - surface prep not usually an issue,
  - waste management tends to be simpler.
- Disadvantages
  - no radionuclide or chemical specificity,
  - likely to be destructive to the surface,
  - airborne emissions,
  - limited access to complex geometries,
  - more "hands-on" potentially leading to higher doses,
  - waste volumes can be larger,
  - set-up issues.

EPA Page-40

Strippable Coatings

These are paints, polymers and related coating materials applied to surfaces with loose removable particulates. The coating penetrate and adhere to the contaminates and then removed by stripping the coating.

EPA Page-41

Strippable Coatings

- Advantages
  - produce a single solid waste,
  - prevents or reduces airborne contaminates,
  - used to mitigate non-rad wastes (PCBs, asbestos, and metals)
  - equipment easy to mobilize,
  - does not require water source to operate,
  - Internal contamination unlikely.
- Disadvantages
  - Temperature dependent (4°C to 32°C).
  - Maintenance issues (e.g., clogging spay nozzle).
  - Respiratory protection likely needed during application.
  - Applicable to easily removed contaminants.
  - Costs: $4.85 per square foot.

EPA Page-42

Strippable Coatings
Uses in an Urban Environment

- Decontamination coating
- Protective coating to prevent spread of contamination
- Fixing loose contamination while other operations proceed
- Viable option but expense may be an issue
- The quality of performance data available to address this factor was judged to be GOOD.

EPA

Concrete Grinder

Uses a diamond grinding wheel to decontaminate and strip concrete surfaces. Applicable to flat or curved surfaces.

Concrete Grinder

- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability

EPA

Concrete Grinder

- Advantages
  - usually results in a relatively smooth surface which can be reused,
  - surface depths up to 1.5 to 3 mm deep,
  - quick and easy compared to similar technologies,
  - less dust generated than scabbler and scaler technologies,
  - reduced worker exposures to contaminants and vibration.
- Disadvantages
  - Smaller sized jobs,
  - Respiratory protection likely needed during application.

EPA

Concrete Grinder
Uses in an Urban Environment

- Especially good at removing paint and light coatings from concrete.
- Fast and mobile, less vibration than scabbling technologies.
- Small size limits utility.
- Often used in combination with other technologies
- The quality of performance data available to address this factor was judged to be GOOD.

EPA

Concrete Shaver

The concrete shaver is an electrically driven, self-propelled system capable of removing contaminants at variable shaving depths up to 0.5 inch.

Concrete Shaver

- Target Contaminants
- Applicable Media
- Waste Streams
- Operating Characteristics
- Performance
- Operating Costs
- Availability

EPA

Concrete Shaver

- Advantages
  - usually results in a relatively smooth surface which can be reused,
  - surface depths up to 0.5 inches,
  - less dust generated than scabbler technology,
  - reduced worker exposures to contaminants and vibration,
  - cost savings vs. scabbler.
- Disadvantages
  - Limited to large open areas with little obstacles,
  - Respiratory protection likely needed during application,
  - Potential weight limitations (100s lbs).

EPA

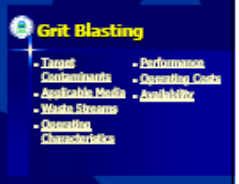
Concrete Shaver
Uses in an Urban Environment

- Especially good at removing paint and light coatings from concrete.
- Fast and mobile, less vibration than scabbling technologies.
- Good for large, flat, open concrete floor and slabs.
- Fast and efficient. Alternative to hand-held scabblers.
- Does not maneuver well over obstacles.
- The quality of performance data available to address this factor was judged to be GOOD.

EPA

Grit Blasting

Abrasive particles are pneumatically accelerated and forcefully directed against a surface. Efficiency is dependent on the chosen abrasive particles, force, target material, and surface characteristics.



EPA

Grit Blasting

- Advantages
  - widely available technology,
  - numerous grit selection for a variety of applications,
  - useful for floors, walls, and irregular shaped items,
  - minimal waste generation if filtration system used,
  - portable to large fixed system capabilities.
- Disadvantages
  - potential dust/airborne emissions,
  - not recommended for plastics and wood.

EPA

Grit Blasting
Uses in an Urban Environment

- Well established technology.
- Different types of grit and blasting equipment are available for a variety of applications.
- Generates dust and particulates during operation.
- The quality of performance data available to address this factor was judged to be GOOD.

EPA

Soft Media Blast Cleaning
(Sponge Blasting)

Soft media blast cleaning uses compressed air to impact the soft media on a surface to loosen, remove, and absorb contaminants in a recyclable media matrix.

EPA

Soft Media Blast Cleaning
(Sponge Blasting)

- Advantages
  - safer for operators compared to other blasting media and chemical stripper systems,
  - easily transportable,
  - waste minimization is achieved by recycling the sponge media,
  - absorbs and removes contaminants,
  - reduces dust generation,
  - virtually no liquid waste,
  - not impacted by complex geometries.
- Disadvantages
  - foam media costs are more expensive than sand blasting media,
  - reasonably large capital investment cost,
  - noisy operation,
  - equipment decon necessary due to limited hose length,
  - feeding operation may be sensitive to humidity.

EPA

Soft Media Blast Cleaning (Sponge Blasting) Uses in an Urban Environment

- Readily available technology.
- Different types of soft-media blasting materials are available for a variety of applications.
- Minimal waste generation.
- Noisy operation.
- The quality of performance data available to address this factor was judged to be GOOD.

EPA

Land and soil decon

Large tracts of contaminated farmland often require some remediation. Common methods are:

Excavation

Deep plowing

EPA

Excavation

- Advantages
  - Best solution – removes the contamination
  - Simple, available technology
- Disadvantages
  - Disturbs the soil horizon – may destroy fertility
  - Generates lots of waste
  - Expensive
  - Not practical for large areas
  - Resuspension

EPA

Deep plowing

- Advantages
  - Removes contamination from surface
  - Simple, available technology
  - Cheaper than excavation
  - Minimal waste generated
- Disadvantages
  - Disturbs the soil horizon – may destroy fertility
  - Expensive
  - Contamination is still present, just concealed
  - Resuspension during operations

EPA

Excavation and deep plowing Uses in an Urban Environment

- Readily available technology.
- Common farm equipment can perform.
- May damage soil.
- Excavation generates lots of waste.

EPA

Road paving

Road resurfacing or paving can address the decon needs of roads and highways.

EPA

Road paving

- Advantages
  - Immobilizes contamination
  - Available technology
  - Minimal waste generated (short-term)
- Disadvantages
  - Contamination still present (may not be protective for strong gamma emitters)
  - May be prohibitively expensive to pave enough roads
  - Recontamination from adjacent areas

EPA

Technology Links

- http://apps.em.doe.gov/OST/itsrall.asp
  - *DOE Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They include a description of the technology, applicable problem areas, and cost and performance data.*
- http://www.orau.gov/ddsc
  - *The Decontamination and Decommissioning Science Consortium provides links for those conducting radiological D&D work.*

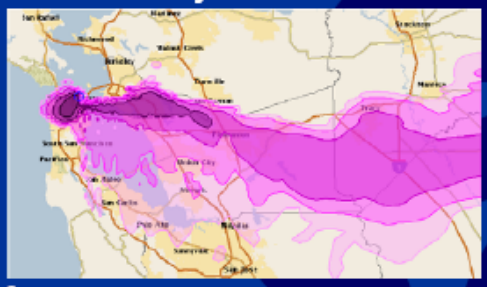
EPA

High Pressure Water

- Advantages
  - useful for difficult to access surfaces,
  - decon complex geometric structures,
  - widely available technology,
  - numerous equipment setups for a variety of applications.
- Disadvantages
  - wastewater containment and treatment considerations,
  - not usable on wood, or fibrous materials.

EPA

3. Today's first scenario RDD "Dirty Bomb" Scenario



EPA

Radiological Dispersal Devices (RDD)

- Both passive and active dispersion
- City or rural
- TTX RDD scenario
  - 2,300 curies of Cesium-137
  - 50 curies of Americium-241
  - Based on combination of DHS and FAS scenarios

EPA

TTX RDD Impact

- 180 fatalities
- 270 injuries
- Relocation:
  - first year 79,200 persons
  - second year 139,000 persons
- Infrastructure damage limited to explosion
- Economic impact up to $billions

EPA

Extent of Contamination

- 1st yr relocation PAG: 1.8 miles/1.2 square miles
- 2nd yr relocation PAG: 2.5 miles/2.6 square miles

Risk Target	Distance (miles)	Area (sq miles)	Exposed (millions)
1×10^{-2}	24	59	0.608
1×10^{-3}	75	538	1.09
1×10^{-4}	75	1,147	1.62
1×10^{-5}	76	1,748	2.36
1×10^{-6}	85	2,633	3.91

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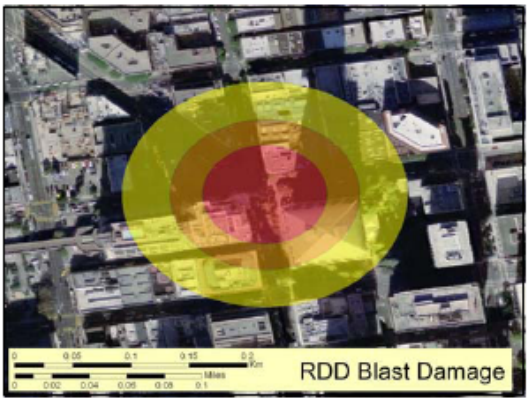

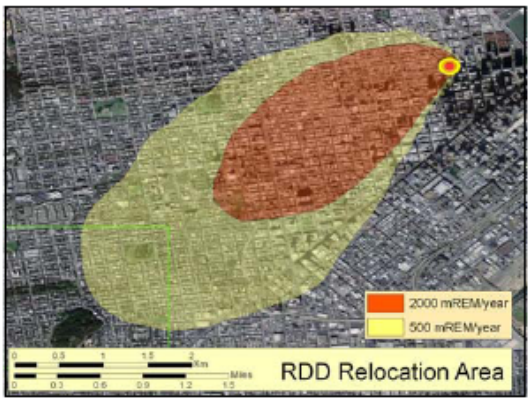

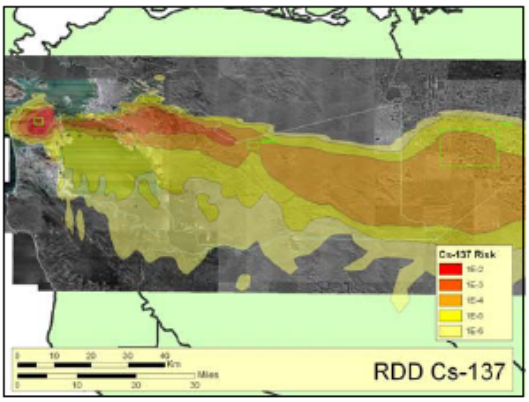

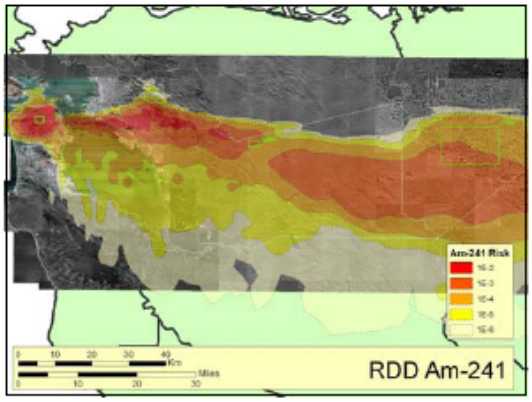

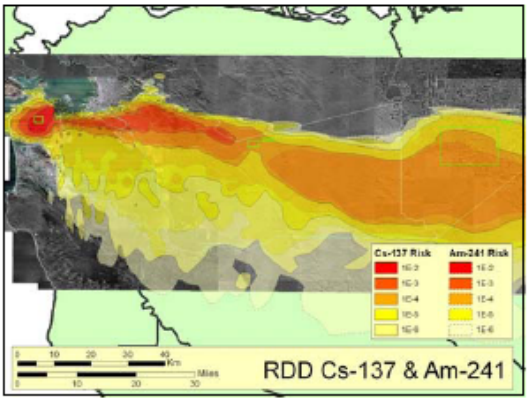

TTX Working Groups

- Urban – Haight Ashbury
- Suburban – Dublin
- Agricultural/open space -- Tracy

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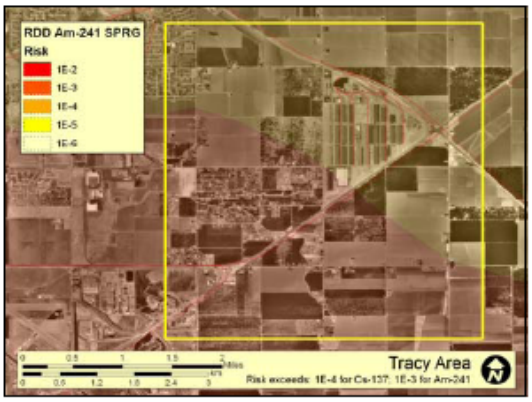

Exercise Outcome: Create TWG Recommendations to the DT

Pre-Event Land Use:		
	Recommended Actions	Rationale
Description of Affected Area		
Final Land Use(s)		
Proposed Risk Level		
Cleanup Levels for Am-241		
Cleanup Levels for Cs-137		
Cleanup Technologies		
Timeframe/phasing for Cleanup		
Proposed Land Use(s) During Cleanup (if different)		
Costs		

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4.
Today's second scenario
IND Scenario

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Improvised Nuclear Device (IND) Scenario

- Homemade or stolen nuclear device
- 10 Kt full yield
- Late-phase cleanup focuses on Cesium-137 and Strontium-90

EPA

Impact

- 229,900 fatalities
- 317,400 injuries
- Evacuation: 1.16 to 2.11 million persons
- Relocation:
  - » first year 1.22 million persons,
  - » second year 521,000 persons
- Infrastructure damage total with 0.5 to 3 miles
- Economic impact up to $hundreds of billions

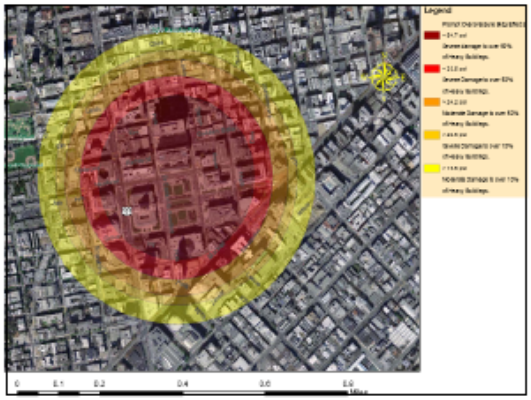
EPA

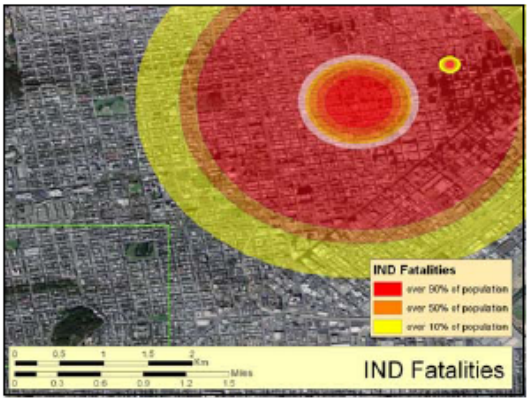
Extent of Contamination

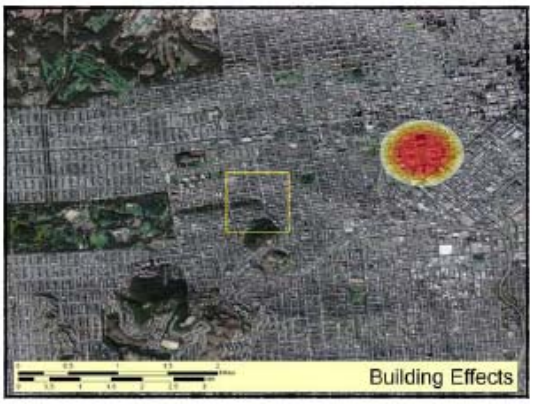
- 1st yr relocation PAG: 175 miles/1,420 square miles
- 2nd yr relocation PAG: 54 miles/171 square miles

Risk Target	Distance (miles)	Area (sq miles)	Exposed (millions)
1×10^{-2}	60	267	0.631
1×10^{-3}	235	2,590	1.35
1×10^{-4}	237	5,767	1.80
1×10^{-5}	238	9,468	2.52
1×10^{-6}	240	16,362	3.68

EPA



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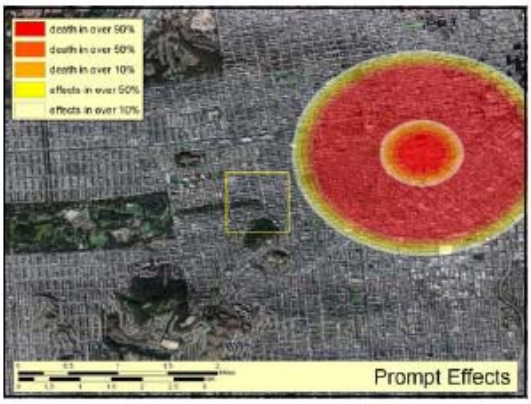
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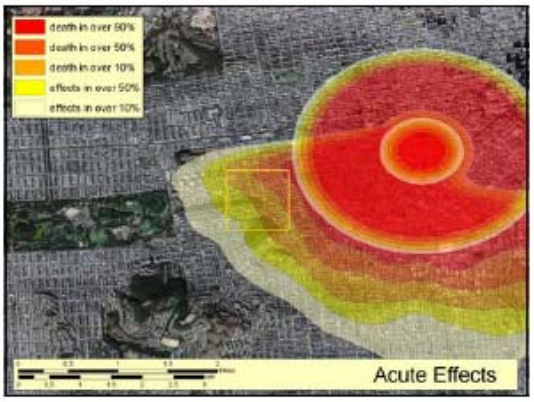
death in over 50%
death in over 10%
effects in over 50%
effects in over 10%
Prompt Effects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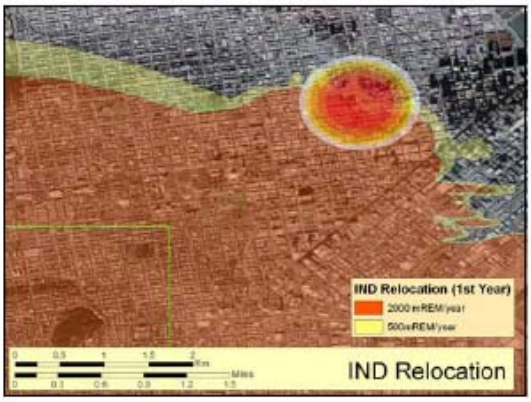
death in over 50%
death in over 10%
effects in over 50%
effects in over 10%
Acute Effects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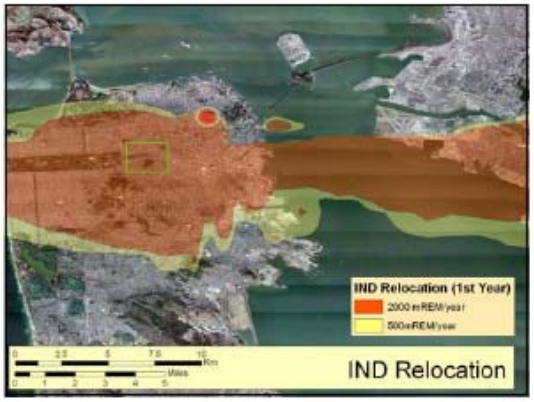
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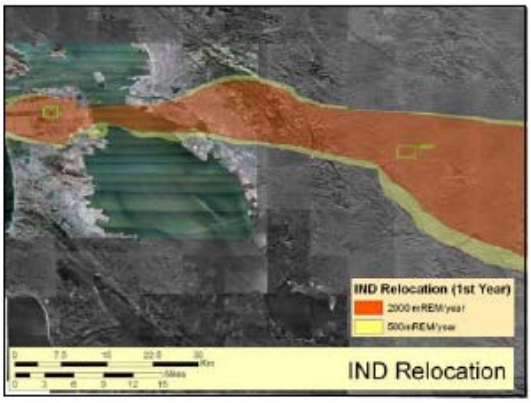
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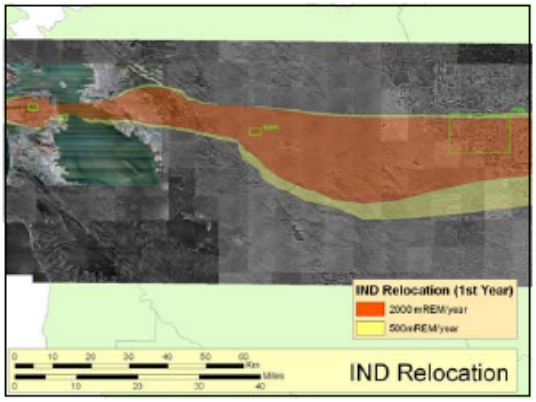
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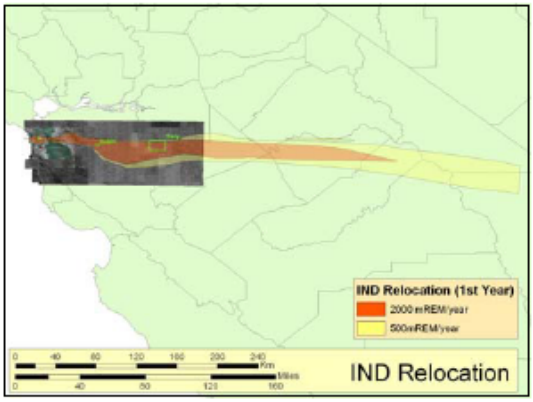
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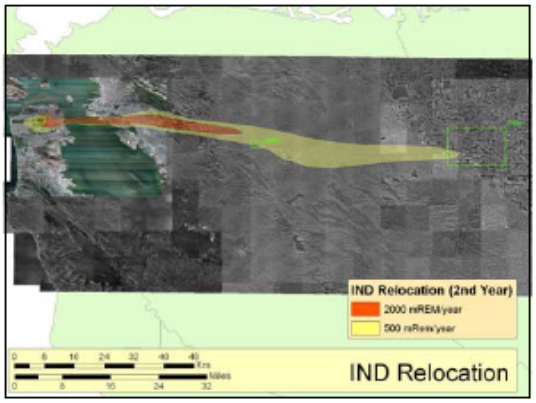
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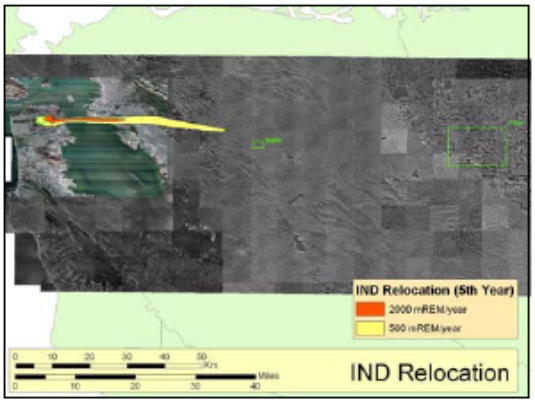
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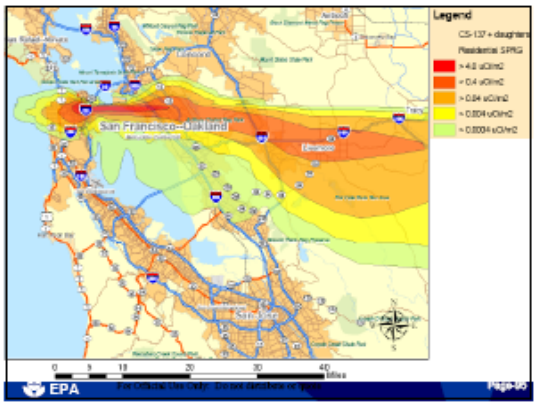
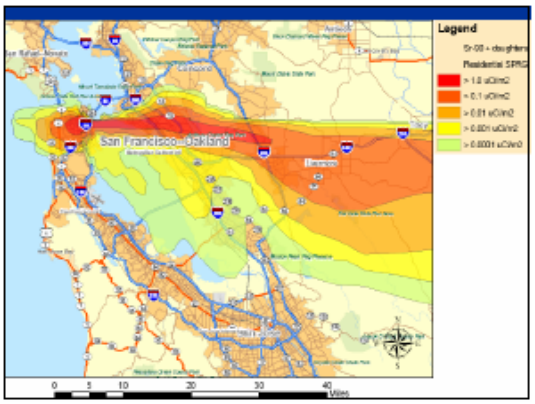
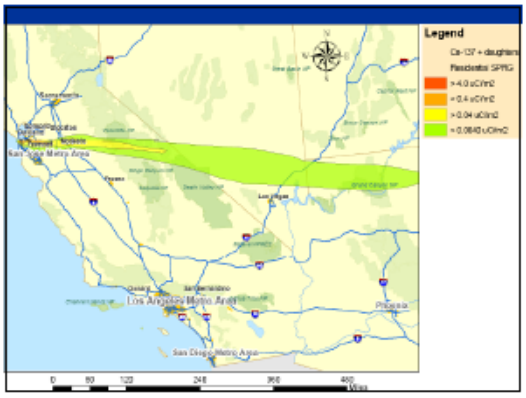

Legend
San Francisco–Oakland
EPA


Legend
San Francisco–Oakland



Compare Cleanup Approach Determined for RDD to the IND Scenario

- What recommendations would need to be changed or adjusted based on this level of contamination?
- How would the decision process and rationale be different from RDD to IND?

EPA